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MERCURY LEVELS IN BERRY'S CREEK

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I. EXECUTIVE SUMMARY

The Department of Environmental Protection has determined that the physical environment in the vicinity of the old Wood-Ridge Chemical Corporation, located in the Borough of Wood-Ridge, Bergen County, N.J. is heavily contaminated with mercury. Excessive levels of mercury can be found in the water, soils, and sediments on and adjacent to the site which is commonly referred to as the "Ventron site". It has further been determined that a zone of heavy mercury contamination extends southward among the marshes, soils, sediments and surface water adjacent to Berry's Creek as far downstream as the Route 3 Bridge (approximately 13,000 feet south of the Ventron site). Above average levels of mercury can also be detected in the air above the site. However, an analysis of blood and urine samples collected from Wood-Ridge and Moonachie residents by the State Health Department, indicates that there is currently no elevated exposure to mercury in area residents.

Despite the heavy contamination in the Berry's Creek ecosystem, the aquatic organisms trapped within Berry's Creek and the surrounding Hackensack Meadowlands continue to be within acceptable federal standards for mercury contamination.

Because of the chemical, physical, and biological properties of mercury, it is the Department's position that mercury levels in aquatic organisms might rise rapidly in the future should water quality conditions in Berry's Creek change. It is this threat that is the Department's greatest concern since the ingestion of contaminated biota is the most probable route by which humans might be exposed to excessive levels of mercury near the Ventron site.

In order to insure that fish trapped in the Meadowlands continue to be safe to eat, DEP plans to monitor these fish for the presence of mercury for several years.

To help reduce the possibility of high concentrations of mercury being found in aqautic biota or elsewhere in the future, DEP has sought legal redress in the State of New Jersey v. Ventron, et al. At the trial DEP sought to have the court order the past and present landowners to remove, abate, and entomb as much of the mercury contaminated creek sediments as possible.

The trial began in May 1978, a draft final decision was filed by the court on August 27, 1979. Pages 63-68 of the judge's decision setting forth the ruling regarding a remedy are enclosed in this report.

II. HISTORY OF OWNERSHIP OF THE SITE

From about 1930 to 1974, a mercury processing plant was operated in the Borough of Wood-Ridge, Bergen County, New Jersey. Most of the tract on which the plant was located, (a portion of which is in the Borough of Carlstadt), was marshland in 1929, bounded on the east by Berry's Creek (See map Fig. 1). Over the course of years, the ownership of the plant and surrounding property changed hands a number of times. The original plant was constructed on land leased to F.W. Berk and Company, Inc. (Berk) on a portion of the forty acre tract that has subsequently become the focus of the New Jersey Department of Environmental Protection's (DEP) investigation and litigation. In 1943, Berk purchased the entire tract, and retained ownership of both the plant and land until 1960.

Little is directly known about the operations at the chemical plant during Berk's ownership (1929-1960). From conversations DEP personnel have had with some of the employees who worked at the plant from the 1950's until its closing in 1974, it appears as though essentially the same type of materials were handled, the same chemical processes employed, and the same products manufactured throughout this period. Assuming that is the case, the main operations at the plant consisted of the manufacture of fungicides, insecticides, red oxide of mercury (ROM), yellow oxide of mercury (YOM), phenyl mercuric acetate (PMA), and other organic and inorganic mercury compounds. The plant also had a distilling operation in which contaminated mercury was purified and mercury was recovered from both in-plant waste, such as "pit sludge", and from customers' waste (amalgams, batteries, thermometers, etc.).

In 1960, the Velsicol Chemical Corporation (Velsicol), an Illinois corporation, formed the Wood-Ridge Chemical Corporation (WRCC), a Nevada corporation, as a wholly owned subsidiary for the purpose of acquiring the assets of Berk and operating the mercury processing plant. The operation of the plant under the ownership of WRCC/Velsicol was essentially the same as under Berk. In August 1960, following the sale of the Wood-Ridge plant and property, Berk filed Articles of Dissolution.

As stated before, a major portion of the forty acre tract originally was marshland. Subsequent to 1960, a portion of the tract, approximately nineteen acres between Berry's Creek and the seven acre mercury plant site, was used as a dumping site. During the Department investigation, we found that in addition to being used primarily for the disposal of demolition material and domestic solid waste, the dumping site also served as the disposal site for most of the mercury plant's industrial wastes, including its chemical wastes. In June 1967 WRCC/Velsicol subdivided the forty acre tract into two parcels; the mercury plant site (seven acres) and the remaining property (thirty-three acres which included the dumping areas). Title to the thirty-three acre parcel was transferred from WRCC to Velsicol, which retains ownership to this day of that part of the property.

In February 1968, Ventron Corporation, a Massachusetts corporation, acquired the stock of WRCC (including title to the 7-acre plant site) from Velsicol. As stated before, the operation of the mercury plant in terms of products and processes remained essentially the same until 1974. During these years WRCC/Ventron was one of the largest domestic processors/users of mercury. In making application to the U.S. Army Corps of Engineers for a permit, WRCC/Ventron reported that at that time, the plant was operating one shift a day, six days a week and occasionally the plant sometimes operated for more than one shift a day.

On May 20, 1974, Robert and Rita Wolf (Wolf) acquired the 7 acre piece of the property from Ventron. In June 1974, the other assets of WRCC were merged into Ventron. Wolf proceeded to demolish the mercury plant, and in 1975 subdivided the seven acre property into two parcels. Title to one of the parcels was transferred to the U.S. Life Insurance Company (U.S. Life) pursuant to a sale and leaseback agreement with Wolf. Wolf retained title to the other parcel. A construction company owned by Wolf, Rovic Construction Company (Rovic), constructed a warehouse on each parcel.

Thus the present owners of the original forty acre Berk tract are:

U.S. Life:	Block 229, Lot 10A; Borough of Wood Ridge	(about 4 1/2 acres)
Wolf:	Block 229, Lot 10B; Borough of Wood Ridge	(about 2 1/2 acres)
Velsicol:	Block 229, Lot 8; Borough of Wood Ridge and Block 146, Lot 3; Borough of Carlstadt	(about 33 acres)

III. HISTORY OF CONTAMINATION OF THE SITE

The Departments involvement with the mercury processing plant in the Borough of Wood-Ridge began in the late 1950's when representatives of the New Jersey Department of Health (NJDOH), a predecessor to the DEP, inspected the Berk plant and sampled its discharge. From the time of this first inspection and through the 1960's, the NJDOH unsuccessfully sought either the elimination of the total industrial discharge or suitable treatment of the industrial discharge to acceptable levels prior to discharging into Berry's Creek. It is important to note that only a few samples were collected for mercury analysis during this time, and the results of these samples were reported as negative (i.e., the mercury concentration in the sample was below the limit of detection for the analytical method then used). The main thrust of the NJDOH's activity with the plant concerned not mercury, but rather the excessive levels of more classical pollutants such as biochemical oxygen demand (BOD) and suspended solids for which analytical procedures were both well established and commonly used. During Berks ownership, attempts were made to connect the industrial discharge into the Wood Ridge sewerage collection system for treatment at the municipal treatment plant, which is located adjacent to the property. In November 1959, the Borough of Wood Ridge advised Berk that its request to discharge industrial wastewaters into the municipal sewerage collection system was denied.

During the WRCC/Velsicol ownership of the mercury processing plant, the plant owners made ineffective attempts to treat the industrial wastewaters prior to their discharge into Berry's Creek. These attempts included additional studies by consultants to determine the pollutant characteristics of the industrial wastewater, treatment of some industrial wastewater in a pilot plant scale, and segregation of some of the internal plant wastewater streams. In spite of the efforts of NJDOH, none of these programs led to the construction of a treatment plant for the plants wastewater. The change in ownership in 1968 to WRCC/Ventron lead to a change in consultants, but for the time being the lack of action continued.

In summary, during the 1960's, the prime responsibility for monitoring the health and safety of Wood Ridge Chemical's operation rested with the N.J. Department of Health; no other public agencies were significantly involved.

In 1970, as a result of publicity generated by a number of mercury contamination and poisoning incidents, many governmental agencies inaugurated an intensive national investigation of mercury users in the United States. This effort was spearheaded by the newly formed U.S. Environmental Protection Agency (EPA9 and over the course of the program, WRCC/Ventron came under increased scrutiny. Since at the time, it was thought that the major problem with Ventrons operation rested with its mercury discharge into the navigable waters of Berry's Creek and the Hackensack River, EPA (using its water pollution regulations) shouldered the major regulatory responsibility; the activities of the newly-created DEP regarding the plant were minimal. With the reduction in Ventron's water-borne mercury discharge and with the discovery in 1974-75 that the soils surrounding the plant were heavily contaminated with mercury, the major regulatory responsibility shifted back into the State's hands, and in particular to DEP (see below).

With the commitment of EPA and with improved analytical techniques, sampling of the WRCC/Ventron industrial wastewater for mercury analysis was conducted. The results indicated that, at that time, the WRCC/Ventron plant was discharging from two to four pounds of mercury a day into Berry's Creek. In addition, the mercury concentration in sediment samples taken in the vicinity of the industrial wastewater discharge into Berry's Creek was reported to be greater than any previously recorded. EPA decided that the contaminated sediments would have to be removed, but that such a decision should be deferred until a solution for the ongoing discharge could be carried out. That decision was never made.

Meetings were held with WRCC/Ventron personnel at which they were advised that by January 31, 1971, they would be allowed to discharge no more than 0.5 pounds of mercury a day, and that this limitation would be further reduced by July 1, 1971 to 0.1 pounds of mercury a day. WRCC/Ventron initiated a two phase industrial wastewater treatment plan which they claimed would achieve the required results. Phase I consisted of the segregation of known mercuric inplant wastewater streams from the non-mercuric streams, isolation of certain drains, and primary treatment of the mercuric wastewaters. Phase I was operational by February, 1971.

Completion of this phase resulted in a reduction in the quantity of mercury being discharged, but brought to light a condition which came to be known as the "residual problem". Samples were taken at two locations described as the "treated effluent" and the "total effluent". The "treated effluent" was the discharge from the Phase I industrial wastewater treatment system. The "total effluent" was the combination of the treated effluent plus all other waste streams (including stormwater, boiler blowdown and non-mercuric process wastewaters) which did not pass through the Phase I treatment system.

The discovery of the "residual problem" resulted in numerous meetings, discussions and correspondence between EPA, DEP and WRCC/Ventron from 1971 until the closing of the plant in 1974. Many avenues were explored in an effort to identify the source of the unexplained mercury in the total effluent and WRCC/Ventron initiated Phase II of its treatment plan (In March 1971). Phase II consisted of chemically treating all mercuric wastewaters, isolation of additional existing lines and drains, repiping, installation of recovery tanks, and treatment of settled sludge; this phase was competed in the fall of 1971. However, the "residual problem" continued and, as a result of the improved treatment of the mercuric wastewaters, became even more pronounced. At the insistence of EPA, WRCC/Ventron initiated a number of additional programs in an effort to explain the "residual problem". Their sampling and reporting frequency was increased, checks of their sampling and analytical procedures were conducted, drain lines were dye tested, soil samples were taken, and other possible mercury sources were connected to the treatment system. WRCC/Ventron was directed by EPA to improve housekeeping procedures, remove potential areas and conditions for mercury contamination, such as inadequate curbing, and institute and maintain a clean analytical laboratory.

Eventually, EPA officials became convinced that the "residual problem" resulted from the mercury contamination of the soil and groundwater beneath the plant and WRCC/Ventron resisted this opinion. In January 1972, WRCC/Ventron contracted to have soil and groundwater samples collected at the plant site. The soil samples contained from 5 to 375 ppm (parts per million) of mercury; the water samples from the soil boring test holes contained from 5.5 to 2,000 ppm of mercury, unfiltered, and from 0.04 to 3.60 ppm of mercury, filtered. Even with these high results in hand, WRCC/Ventron took the position that subsurface infiltration appeared as a minor source of mercury in the total plant discharge. (During the course of the State litigation, a Ventron report entitled "Long Range Facilities Plan 1972-1977", dated June 1972, came to light. The report concludes, in part: "The plant can no longer meet current mercury exposure limits---which were tightened in the last six months. An intensive cleanup and housekeeping campaign provided perceptible but insufficient improvement; the plant is a veritable Agean stable of residual mercury.") Until the closing of the plant in 1974, analyses of both the total effluent and treated effluent continued to show an uncontrolled release of mercury into the plant discharge system.

As some time toward the end of this period, Ventron decided to sell the business and property of WRCC (the seven acre plot). This decision was not made known to either EPA or DEP until the plant was closed. On May 7, 1974, a DEP inspector found the plant abandoned with demolition equipment on site.

With the transfer of title to Wolf and the demolition of the mercury plant, the full extent and complexity of the contamination began to unfold. In June 1974, a discharge of oil caused by the demolition of the plant again brought the property under scrutiny by DEP and EPA.

Wolf's plan was to construct two warehouses on the property; Building No. 1 on the westerly side (U.S. Life parcel) and Building No. 2 on the easterly side (Wolf parcel). The site of Building No. 2 was the location of most of the process operations of the old mercury plant.

The first set of what was to be an ever expanding series of soil samples by public agencies was collected and analyzed in July 1974. The results of these samples indicated that the soil contamination by mercury on the site of the proposed Building No. 2 overshadowed the contamination which existed on the Building No. 1 site. The concentration of mercury in the soil of the Building No. 1 site ranged from 185 to 3215 ppm compared to a range of from 1775 to 195,000 ppm at the site of Building No. 2 (195,000 ppm is equivalent to 19.5%). Following review of these results, a meeting was held on August 16, 1974, attended by representatives of DEP, EPA and Wolf at which a "Memorandum of Understanding" was executed. The "Memorandum of Understanding" detailed the conditions, including additional soil sampling and soil removal, to be met prior to commencing construction of Building No. 1. In accordance with the "Memorandum of Understanding", no construction or field work was to be done on the site of Building No. 2 until additional soil samples were taken and evaluated. Construction of Building No. 1 began in September 1974.

During the latter half of 1974 and into 1975, a major effort was made to determine the feasibility of recovering the mercury from the soil of the Building No. 2 site and/or disposing of the contaminated soils in an acceptable fashion. During this period, until all leads were exhausted and it became obvious that decontamination and removal were both impractical, DEP and EPA took the position that such removal was necessary. More than a dozen appropriate individuals and corporations in the mercury mining and related industries were contacted in this regard. Many requested and were sent samples of the contaminated soils for test processing. Their reponses were the same; recovery was not feasible. No one could be interested in pursuing the project.

In January 1975, Wolf's engineer submitted a multiphased proposal for the entombment of the contaminated soils followed by warehouse construction on the Building No. 2 site. (This entombment proposal is similar to the request DEP has brought before the court for the entire 40 acre site.) On February 28, 1975, EPA responded to this proposal in what has since been referred to as the "Scolnick letter". The "Scolnick letter" stated that certain portions should be implemented immediately; that the property be covered with impervious paving that all drainage from the property should be carried by drainage ditches constructed of water-impervious materials; that a monitoring program should be established; that semi-annual inspections should be conducted of all aboveground structures constructed to mitigate mercury pollution; and further, that all cracks in paving and drainage should be repaired within fourteen days of their detection. Further, the letter said that the conditions and stipulations set forth in the agreement should appear in deeds executed in transference of ownership of proprietorship of the property involved and that such stipulations become a covenant running with the land and be recorded in the County Clerk's Office. Wolf took exception to those portions of the proposed agreement involving monitoring, the submission of reports, and deed restrictions. Negotiations concerning the agreement continued through 1975 to no avail. Construction of Building No. 2 began in late 1975. This construction incorporated some of the conditions contained in the "Scolnick letter" (e.g. paving). Wolf had been advised on many occassions by DEP that he would be proceeding at his own risk if he began construction of Building No. 2 prior to having an executed agreement with DEP and EPA.

During 1975, EPA determined that the Wolf matter was not within their legal jurisdiction and ceased their active involvement. DEP then, acting alone, undertook the legal and scientific steps needed to seek judicial relief. On April 9, 1976, DEP commenced suit against the present defendants, which include all past and present landowners.

Having arrived at an impasse with Wolf and in concert with the initiation of the lawsuit, DEP expanded its own investigation of mercury contamination in the surrounding areas. During 1976 two soil sampling programs were conducted on the Velsicol property (thirty-three acre site). The results of this sampling indicated that the contamination extended throughout the Velsicol property. In one sample of soil collected in September 1976, beads of mercury could be seen in the sample when viewed through a microscope at low magnification. As a result of these samples and the findings of Jack McCormick and Associates, Inc. (JMA) in their environmental studies for the New Jersey Sports and Exposition Authority, DEP undertook an even more extensive monitoring program for mercury and other heavy metals in April 1977. This ongoing program, originally focused on the Velsicol/Wolf/U.S. properties and the condition of Berry's Creek, has been expanded to include the entire Hackensack Meadowlands area as well as other areas in the State, so that the data from this site can be seen in a broader perspective.

The initial field study in DEP's extensive monitoring program took place from May through July 1977. This study involved a major manpower effort on the part of DEP and the Hackensack Meadowlands Development Commission (HMDC) personnel, and included in contracting with JMA for the collection, analysis and evaluation of samples on and in the area of the Velsicol/Wolf/U.S Life properties, and contracting for technical support from EPA units throughout the country.

IV. MERCURY CONTAMINATION

As a result of our investigation into the problems associated with the use of mercury at the Ventron chemical company plant, we have discovered that the soils; sediments, and water surrounding this property are grossly contaminated with mercury. Although data has been collected concerning the levels of mercury in nearby aquatic and terrestrial biota and in the air at the site, these data, as will be seen later, are more difficult to interpret.

Our findings to date have understandably generated concern among state agencies (such as NJDEP and NJDOH), legislators, and the general public and others about the potential adverse health effects that might be associated with this degree of contamination. In evaluating the problem, DEP has considered several basic issues that relate to the total geological and biological life cycle of mercury. These issues are:

1. The toxicity of mercury and mercury containing compounds.

2. The transformation, distribution, and transportation pathways of mercury compounds.

3. The quantities of mercury contaminating the Berry's Creek ecosystem.

4. The potential for unacceptable health risks to humans.

The following pages describe our findings to date regarding these issues, and our recommendations for abating the problem.

1. Toxicity of Mercury and Mercury Compounds

Mercury is a naturally occurring metallic element found throughout the environment in air, water, soils, and biota, albeit in generally low concentrations. Mercury is not known to be an essential element in the biosphere although it is assimilated by all organisms. In the elemental state, mercury exists as a silvery liquid (in the form commonly found in thermometers and light switches) and like many other liquids, can change from the liquid to the gaseous state with relative ease at normal temperatures. In addition to its occurence in its elemental state, mercury is capable of combining with many other elements to form compounds with differing chemical and physical properties and with differing intrinsic toxicities. This fact complicates any assessment of the hazards associated with mercury contamination.

The degree of toxicity of environmental mercury is very much dependent upon its form and how it enters a biological organism. For example, metallic (elemental) mercury is not particularly toxic to humans when ingested, while inhalation of metallic vapors has long been known to have an adverse effect on human health. Excessive exposure to mercury vapor usually occurs only among occupationally exposed individuals, although it can occur from the presence of small amounts of spilled mercury in an enclosed environment. In the latter case, high concentrations of the vapor can result in such symptoms as inflamed gums, tremor, presonality disturbances, and kidney and respiratory injury. According to the World Health Organization (WHO), no demonstratable effect, even a minor one, has been documented among occupationally exposed workers inhaling less than 50 ug/m^3 micorgrams per cubic meter) of mercury. Because elemental mercury is insoluble in water and is not readily absorbed by biological systems, there is little buildup or bioaccumulation of metallic mercury in the food chain.

As noted above, elemental mercury can combine with other elements to form a wide variety of other compounds. One major class of compounds is the so-called "inorganic mercury" compounds or "salts", such as mercuric chloride or nitrate. Some of these mercury salts are highly reactive, are corrosive compounds to tissue, and possess moderate toxicity. A second class of mercury compounds are the "organic" mercurials. These are mercury compounds in which the mercury is tightly bound to carbon atoms. Included in this group is a sub-class called alkylmercurials, of which methylmercury is one example.

From the point of view of human health, the most important forms of mercury are the elemental vapors form (which has been previously described) and the organic compounds (particularly the short chain alkylmercurials). This latter class poses a threat to human health for the following reasons.

First, alkylmercurials, particularly methylmercury, can accumulate to high concentrations in living organisms due to the fact that they are readily absorbed by the intestinal tract (and in fish by the gill membrane), they bind tightly to protein, and they are excreted slowly. As a result, methylmercury can bio-accumulate in the food chain so that even minor concentrations in water can build up to much more significant levels and potentially toxic levels in aquatic systems. Second methylmercury readily passes through the placental and blood-brain barriers, causing fetal injury as well as irreversible nervous system damage. While the symptoms of poisoning by organic and inorganic mercury compounds are generally the same, major differences in rate of absorption and excretion make the organic compounds more toxic. These types of mercury compounds can act on the nervous system, affecting vision, hearing, muscle coordination, and behavior. The tragic incident of mercurial poisoning in Minamata Bay, Japan, is an example of severe poisoning due to the ingestion of mercury-contaminated fish that had bio-accumulated high concentrations of mercury from the water and the aquatic food chain. In fact, for nonoccupationally exposed individuals, the most significant route of entry of organic mercury is through ingestion of contaminated foodstuffs, particularly fish.

2. Transformation, Distribution, and Transportation Pathways of Mercury

In assessing the significance of the mercury contamination in the Meadowlands district, DEP has considered several issues relating to the geological and biological life cycle of mercury. As depicted in Figure 2, mercury in the environment is subject to an array of physical, chemical, and biological processes. For example, mercury in contaminated soils can be transported to other environmental mediums such as stream sediments, water, and air through soil erosion, groundwater transport, and volatilization. In addition, biological systems may modify environmentally contaminated areas through the ingestion, inhalation, absorption, and adsorption of mercury. Therefore, in assessing the potential for environmental damage due to the contamination of soils, it is important to consider the potential for mercury to spread out and move into the neighboring ecosystem through all of the above-mentioned processes.

A more difficult problem to assess is the potential for the chemical transformation of mercury. This process is illustrated in Figure 3. "Transformation" here means that one form of mercury is transformed (by biological or non-biological means) to a different compound, for example, the transformation of inorganic mercury compounds to organic mercury compounds. Because of the greater toxicity of methylmercury compounds and their high rates of absorption by biological systems, rates of transformation to methylmercury are especially important in evaluating the health hazards of mercury contamination. Although the mechanisms controlling the rates of methylation are highly complex, a major component of the process are certain microorganisms that reside in soils and sediments known as methylating bacteria. In addition, it should be noted that a demethylation process occurs (the conversion of methylmercury into inorganic mercury) and this also is mediated by micro-organisms.

The factors controlling the rates of methylation and demethylation are highly complex and not fully understood. However, it is known that these rates in aquatic systems are controlled by such factors as pH, oxidation-reduction potential, nutrient loadings, degree of contamination, sedimentation rates, and certain other physical and chemical parameters. In an ecosystem undergoing dynamic change (such as Berry's Creek), minor perturbations in any one of these factors may significantly increase or decrease the rate of methylation.

Once methylmercury is formed it is rapidly absorbed by biological organisms where it can then enter the human food chain primarily through the consumption of fish. In fact , at present, the most effective indicators of mercury pollution in an ecosystem and the potential hazards this poses to humans and wildlife are the mercury content in the fish in the ecosystems. In using this indicator, it is important that factors such as age, species, and nutritional habits of the fish be taken into account.

Regarding the contamination at this particular site, DEP's concern rests not only with the degree of soil contamination at the site itself; even more important is DEP's concern that the relatively less harmful inorganic mercury compounds on the site, given certain conditions, might be converted to methylmercury which can be rapidly absorbed by the biota in the area and thus potentially delivered to man.

In summary, different forms of mercury have differing toxicities. From the standpoint of human health, the most toxic form is methylmercury. In areas of gross contamination, the action of physical and biological process can result in the transport of mercury in a relatively non-toxic form and from zones of relative environmental isolation (such as tightly bound to soils) to areas where micro-organisms and other biota can transform the mercury into methylmercury. In this form, any methylmercury present in an aquatic ecosystem can be rapidly absorbed by the biota. In order to assess the current magnitude of danger to biota and to humans at the Ventron site, the most effective indicator is the mercury content in finfish and shellfish. In the absence of any cleanup or abatement activities at the Velsicol site, mercury concentrations in fish may fluctuate depending on how minor perturbations in the aquatic ecosystem (such as physical and chemical parameters, pH, water quality, nutrients, etc.) affect the rates of methylation and demethylation.

3. Quantities of Mercury Contaminating the Velsicol/Wolf Properties and Adjacent Meadowlands

For the purpose of evaluating data regarding the levels of mercury contamination at the Velsicol site and in the Hackensack Meadowlands ecosystem as a whole, DEP has relied upon the following major studies (funded by or done at the request of DEP).

1. "An investigation into the aquatic and terrestrial mercury contamination in the vicinity of the former location of the Wood Ridge Chemical Corp." by Jack McCormick Associates (hereafter known at JMA), August 1977.

2. "Concentrations of Mercury in the Hackensack Meadowlands Ecosystem" Final Report of HMDC to DEP, December, 1978.

3. "Report on the Investigation of the Ventron/Velsicol Properties and the Berry's Creek System" by Reed, Hutchinson and Perez of DEP (hereafter the Reed report), 1977.

4. "Air Monitoring Report", U.S. Environmental Protection Agency, October, 1978. Report to DEP.

5. "Heavy Metal Contamination in Aquatic Systems-Bimonthly Reports to DEP 1-3" from the New Jersey Marine Sciences Consortium. June-October 1978.

6 "Mercury Concentrations on Moonachie/Wood Ridge Residents" NJDOH report (unpublished), September 20, 1979.

7. "Biomonitoring and Assessment for Mercury in Aquatic Fauna of Berry's Creek Tidal Marsh and Adjacent Biozones. Reports to DEP 1-3" New Jersey Marine Sciences Consortium. July 1979-August 1980.

The results of these reports are all available for inspection at DEP's Office of Cancer and Toxic Substances Research. Below is a description of the major findings of these investigations.

Soils

Evidence accumulated by DEP indicates that the soils surrounding the Velsicol and Wolf properties are extremely contaminated with mercury. The zone of greatest contamination extends from the Velsicol/Wolf property along the marshes adjacent to Berry's Creek downstream to the Route 3 Bridge.

Evidence of this contamination is available from several sources. Visual inspection of the land currently owned by Velsicol Chemical Company provides qualitative evidence of this contamination. Early maps indicate that the Velsicol property was once unfilled natural marsh and meadowland. Over the years, this once-productive area has been filled in with sanitary wastes, demolition debris, and chemical wastes whose remains are still visible. Even today, a cursory examination of some of the discarded reagent bottles that are found in plentiful supply on the site reveals beads of mercury. During the trial of the State of New Jersey vs. Ventron Corporation, et. al. lawsuit, the testimony of former Ventron employees corroborates the visual evidence, namely, that the land behind the chemical process building was used for the disposal of mercury-laden chemical wastes.

Two studies funded by DEP provide quantitative evidence of gross mercury contamination of the soils. Table 1 lists background mercury concentrations typical of soils from differing regions. The mercury concentration in most natural soils rarely exceeds 1 part per million (ppm). In contrast, research conducted by JMA and HMDC reveals concentrations of mercury in the soil at this site upwards of tens of thousands of ppms (10,000 ppm = 1% mercury).

In 31 core samples analyzed at various depths (to 18 feet), collected from areas on or adjacent to the Velsicol/Wolf properties by JMA, mercury concentrations ranged from .7 ppm to 123,000 (see Table 2 for results and Figure 1 for sampling locations.

Among these core samples, 4 stations averaged over 1000 ppm, 10 were between 100-1000 ppm, and 17 were below 100 ppm. All stations averaged over 1 ppm mercury. Utilizing this data, DEP estimates that as much as 160 tons of mercury are buried on the property owned by Velsicol. Although this figure has been challenged, the most conservative opposing points of view place the value at 30 tons, which by itself is a significant amount of contamination. Aside from the mercury on the Velsicol tract, considerable amounts are present on the Wolf property. A consultant hired by Wolf found mercury concentrations in the soil as high as 195,000 ppm. DEP estimates that as much as 129 tons of mercury contaminate this property. Therefore, DEP has estimated that a total of 289 tons of mercury may lie beneath the soils of the Wolf/Velsicol properties.

A major concern of DEP is whether the 129 tons of mercury under the Wolf property are presently adequately entombed, and thereby removed from the environment at large. Mr. Wolf did construct a cutoff wall along one side of the property to isolate the property from the influence of tidal groundwater movement. With this containment wall on one side, and with the contaminated areas covered on top by the current warehouse buildings, it has been asserted by Mr. Wolf that the mercury is entombed on the site. However, it is DEP's contention, based on our study of groundwater movement underneath the Wolf warehouse and based on our determination that a gradient of dissolved mercury may exist near the property (with highest values located underneath the Wolf warehouse) that the mercury is not effectively sealed off and contained. If DEP's contention is true, then the potential exists for the mercury under the Wolf property to ultimately contaminate the wider environment through groundwater transport of dissolved mercury or through the movement of mercury bound to fine sediment particles traveling through the interstitial voids and gaps of the landfill (see the section below on groundwater). Thus the question of the effectiveness of the entombment on the Wolf property is one issue brought before the court.

Irrespective of the issue of entombment of the 129 tons of mercury on the Wolf property, the 160 tons on Velsicol's property also presents a potential threat to the environment. Until this mercury in entombed or otherwise removed from the environment, it has the potential for moving out of the soil into other parts of the ecosystem through the processes of erosion, groundwater transport, volatization and biological transformation uptake. Although the mercury present on the site is probably primarily inorganic mercury, it could be transformed to the more hazardous methlymercury by the sediment and soil microorganisms. Once formed, this methlymercury will be readily taken up by aquatic biota.

Evidence that the zone of soil contamination now extends outwards from the Velsicol property into the surrounding Meadowlands is available from the study conducted by HMDC. During this study, 49 core samples of marsh soils were collected from the varied bio-zones of the Meadowlands and analyzed. The sampling locations are shown in Figure 4. Mercury concentrations at 2" soil increments in the different core samples ranged from nondetectable to 2006 ppm. The data indicates that the wetlands in the Meadowlands district may have mercury levels greater than the typical background concentrations found in pristine areas. The area adjacent to Berry's Creek from the Route 3 bridge upstream; to the tidegate is especially contaminated. This is evident when the peak mercury concentrations in each core sample are plotted out on the map as shown in Figure 5. Note that 11 out of 14 sites downstream from the tidegate along Berry's Creek exhibit peak mercury concentrations exceeding 100 ppm. In the other portions of the Meadowlands, this peak level was attained in only 1 of 36 core samples. Average mercury concentrations in the top 4 inches and 18 inches of soil are shown in Table 3; the average mercury concentration exceeded 50 ppm in 10 stations along Berry's Creek, but in only one station outside of Berry's Creek. In fact, 5 of the Berry's Creek stations exceeded 500 ppm.

Sediments in Waterways

The distribution and quantities of mercury present in the sediments of the Hackensack Meadowlands waterways closely follow the trends observed in nearby marsh soils. Again the highest levels were detected in close proximity to the Velsicol property, falling off with distance downstream toward the Route 3 Bridge.

As discussed previously, EPA's 1970 investigation revealed that an average of 2.1 pounds of mercury was being discharged daily into Berry's Creek. Sediment samples collected by EPA 100 yards upstream and downstream from the discharge pipe had concentrations of mercury as high as 8,475 and 7,740 ppm respectively. Sediments collected in the close vicinity of the discharge pipe contained 2,825 ppm of mercury in the top 3 inches of sediment, and 39,420 ppm in the 3-6 inches layer, 89,162 ppm at 6-9 inches and 66,553 ppm at 9-12 inches. Concentrations in the thousands of parts per million are indicative of gross contamination, this becomes evident when these values are compared to other readings collected from sediments from unpolluted waters. Estuarine sediments in the U.S. generally have been found to contain an average of 0.33 ppm of mercury. Almost all of the sediments collected north of the Route 3 Bridge in Berry's Creek exceed this average background level by 2-4 orders of magnitude. According to one EPA expert brought into court by DEP, the levels of mercury in Berry's Creek sediments are the highest reported levels from intertidal sediments by a factor of 45.

The most expensive sediment sampling in the Meadowlands to date has been conducted by HMDC. These results follow the same general trend regarding the quantity and distribution of mercury as in nearby marsh soils. The concentrations of mercury in the analyzed core samples in 2" increments ranged from less than 0.1 ppm to 1730 ppm. The average concentrations of mercury in 0-4 inches and 0-18 inches of channel sediments are presented in Table 3. Mercury concentrations exceeded 100 ppm in the 0-4" sediment cores of soils in the three Berry's Creek stations, but were below 20 ppm at all other locations except one. During 1978, HMDC conducted a separate sediment study in Berry's Creek. Sediments from the 25 stations from the tidegate adjacent to the Velsicol property downstream to the Route 3 bridge were analyzed at 0-4 inches and 4-8 inch depths. The 25 stations were equidistant from each other, approximately 500 feet apart. The variation in mercury concentration at the two different depths at each of these stations is shown in the graph marked Figure 6.

When the 25 stations are grouped together in groups of 5, a trend is readily visible as shown in Figure 7. Significantly more mercury was found in the sediments collected nearest to the tidegate, than in those downstream. The five stations closest to the tidegate had an average concentration at the 4-8 inch depth of 864 ppm, while the 5 near the Route 3 bridge had an average concentration of only 15 ppm.

Samples collected by DEP one year earlier from Berry's Creek show the same general trend as the samples collected by HMDC (Reed report). As shown in Figure 8, the mercury concentrations in Berry's Creek sediments rise dramtically at the discharge pipe, and gradually decrease further downstream to Route 3. (Note: the absolute values reported by DEP compared to HMDC are much lower because the DEP samples at the time were reported as wet weight, which understates the mercury concentration due to the presence of water; HMDC samples were reported as dry weight.)

<u>Water Quality</u>

The average concentration of mercury found in U.S. streams and rivers ranges from 0.01-1 ppb (parts per billion) with a mean concentration of 0.03 ppb (NAS 1978). Currently, DEP has a standard for the minimum allowable concentration of mercury in surface waters 5 of ppb. EPA (1976) has suggested criteria levels for the protection of freshwater and marine aqauatic resources of 0.05 and 0.1 ppb respectively. Compared to either of these suggested or existing standards, mercury concentration in the surface waters of Berry's Creek are high.

Analyses of surface water throughout the Meadowlands have been performed by HMDC. In their survey, surface water was collected monthly at 8 separate locations (3 in Berry's Creek) in the Meadowlands at high and low tides. A map of the sampling sites is shown in Figure 9. Filtered and unfiltered water samples were analyzed. Because most mercury compounds are only slightly soluble in water and have a high affinity for sediment particles, most mercury present in water is attached to the sediment. Filtering (removing all sediment) before testing thus reveals only how much mercury is present in dissolved form, which for the filtered samples by HMDC was usually below limits of detection. In using unfiltered samples events which dislodge and entrain sediments (such as heavy rain storms) increase the apparent mercury content.

The low tide results of HMDC's surface water study are presented in Figure 10a and b. In these figures the low tide mercury concentrations for the three Berry's Creek sampling stations (6-8) were averaged together on a monthly basis. The same procedure was used for the remaining stations (1-5) outside of Berry's Creek. An increase was detected at all stations in April 1978, reflecting the increased entrainment of sediments following the intense thunderstorms prior to sampling. (The high average value detected in the stations outside of Berry's Creek in April can be attributed to one anomolously high reading detected at station 3.) Overall, the yearly pattern clearly shows that the mercury concentration in Berry's Creek significantly exceeds the levels detected elsewhere in the Meadowlands. In the total collection of 176 unfiltered samples, 7 samples collected from Berry's Creek exceeded the 5 ppb standard while only one sample collected from site 3 elsewhere (in particular just downstream of Berry's Creek) exceeded this standard.

Compared to the average mercury concentrations found in other streams the surface waters of Berry's Creek contain significantly higher amounts of mercury. For example, in a survey of 146 water samples collected from various river basins in northeastern New Jersey (including Essex, Hudson, Union, and Bergen Counties), DEP has found that most samples contain only insignificant amounts of mercury (see Table 4). Only 3% of these samples exceeded 0.3 ppb of mercury. Compared to this, 26% of the stations in the Hackensack Meadowlands (excluding Berry's Creek) and 92% of the Berry's Creek stations exceeded this level.

Groundwater Quality

Because of the low solubility of mercury compounds and the high affinity of mercury for organic matter (as in soil), large quantities of free dissolved mercury are not expected in groundwater, even in areas of gross soil contamination. Of 10 wells examined by JMA on the Velsicol/Wolf property, 8 wells contained no dissolved mercury in the groundwater above the analytical limit of detection (0.3 ppb). (For comparison, even though this water is not used for drinking, the EPA 1976 drinking water standard for mercury is 2 ppb.) However, two wells located just south or east of the Wolf warehouse buildings (wells WS and WE--see Figure 1) did contain mercury capable of passing through a filter at a relatively high concentration. In two measurements taken at WE, the mercury concentrations were above the EPA standard, namely, at 4.3 and 8.8 ppb. One additional well located in the middle of the Wolf warehouse building contained 67 ppb of mercury in the filtered water sample. It is DEP's position that these data indicate that there is mercury dissolved in the groundwater in the immediate vicinity of the Wolf warehouse building. Furthermore, the gradient of mercury concentrations between the outside and the inside of the containment wall of the Wolf building, combined with a report of tidal action within the warehouse building, further indicates that the contaminated groundwater can leach out from the containment area into the nearby environment. On the Velsicol property, there is no equivalent evidence at this time that shows mercury in dissolved form to be moving through the groundwater out into Berry's Creek. However, because the Velsicol site is a landfill, it contains many gaps and voids. DEP therefore believes that mercury attached to sediment particles is moving through these interstitial gaps into Berry's Creek. However, to date neither DEP nor its opponents in court have been able to find a generally agreed-upon scientific technique that could show how extensive this movement actually is at this time.

Air Quality

It is much more difficult to monitor mercury in the ambient air than it is to measure mercury in soil, water and living things. Thus air data at this time is relatively meager. Two sampling campaigns to monitor volatile mercury at the Velsicol/Wolf site have been conducted by EPA at DEP's request. In a preliminary study performed in 1977, values of mercury vapor behind the warehouse buildings located on the Wolf properties ranged from 0.1-0.4 ug/m^3 (micrograms per cubic meter). A more extensive and rigorous monitoring program was conducted in August 1978 by the Environmental Monitoring and Surveillance Laboratory from EPA's Research Triangle Park facility. Volatile mercury was monitored over a 5 day period at 3 sites on the Velsicol property whose locations are shown in Figure 11. One 8 hour sampling was performed inside one of the warehouse buildings. Over the 5 day period, air samples were collected at 8, 12, and 24 hour intervals. (In assessing these data, one must remember that mercury evaporation from soil increases rapidly with increasing temperature, and ambient mercury concentrations in air are expected to increase accordingly.)

Conditions on the site during the sampling were for the most part hot and humid; on the other hand, the soil was quite wet as a result of a severe thunderstorm that occured during the sampling. Although the rain itself would wash out and reduce mercury levels, the effects of damp ground on ambient air levels are unknown at this time. EPA sampling equipment was designed to distinguish total (organic, inorganic, and elemental) mercury vapor from the inorganic and elemental mercury. In reality, the sampling and analysis variations were larger than the differences detected by the two sampling systems, indicating that the organic mercury vapor levels were not highly significant. All data are reported therefore as elemental mercury. As shown in Table 5, the concentrations of mercury detected by EPA from 0.29 ug/m^3 to 3.3 ug/m3. The average concentrations at sites 2, 3 and 4 during the 5 day sampling period were 0.76, 103 and 1.5 ug/m^3 respectively. The results of the 24 hour sampling at each site and each of the 5 days are shown in Figure 12.

For comparison, Table 6 lists typical ambient mercury concentrations for selected locations. The mean mercury level in urban areas is .007 ug/m^3 (microgram per cubic meter) which is approximately 500 times less than the peak amount detected at the Ventron site. In addition, in the New Jersey atmospheric pollution monitoring program for toxic metals sponsored by OCTSR, it was found that the average particulate mercury concentration in ambient air in New Jersey during 1979 was 0.0008 ug/m^3. Therefore, mercury levels found at the Ventron by EPA were over 1000x higher than the levels found elsewhere in New Jersey. Although the 3 ug/m^3 detected at the Ventron site is indicative of the presence of mercury air pollution, according to the World Health Organization no demonstrable effects (even minor ones) have yet been established for occupational exposure in workers inhaling an average less than 50 ug/m^3, on a 8 hour day, 5 day work week. A rough 24 hour 365 day equivalent value of 50 ug/m^3 for 8 hours would be a level of 15 ug/m^3.

Therefore, the results of the air monitoring indicate that while the levels are sufficiently high as to warrant further surveillance, particularly during the warm weather months, the levels are not high enough to indicate any immediate health threat to either nearby residents or workers. DEP bases this opinion on several facts. First, the 3 ug/m^3 value was the peak, not the average, value; the average for all 3 sites combined over a 5 day period was approximately 1 ug/m^3. Second, a DEP air modelling analysis estimates that even, under worst case weather conditions, the approximate concentration at local residences would be 1/3 the ambient on-site level. Third, the measurements were taken in summer, at a temperature that would tend to maximize ambient air levels. Finally, the area of highest mercury concentrations are used by the public only infrequently. However, to insure the well being of local residents, the New Jersey Department of Health collected samples of human blood, hair, and urine from local residents for testing for mercury contamination. This information, which is discussed below in more detail, is consistent with DEP's opinion.

DEP has emphasized that it intends to continue efforts on air monitoring in addition to other monitoring efforts.

Levels of Mercury in Wildlife and Biota

Of greater importance than the concentration of mercury in the physical environment is the concentration of mercury in the biosphere; this continues to be a concern of DEP. Excluding occupational exposure, the primary contributor to the body burden of mercury is the ingestion of mercury contained in foodstuffs, primarily finfish and shellfish. Even without any man-related sources of mercury, finfish and shellfish contain more mercury than other categories of food, with 80-90% in the form of methylmercury. In areas of moderate contamination, the concentration of mercury in fish may range from 0.01-3.0 ppm; in freshwater lakes and highly polluted bays (such as Minamata), values in the range of 20-35 ppm have been detected. Because mercury in the form of methylmercury is readily absorbed by fish from the food they eat as well as directly across the gill membrane, and because methylmercury is excreted only slowly, even small quantities present in water may be concentrated to high levels in the aquatic biota. In fact, most of the mercury present as dissolved methylmercury is "mopped up" by these living things. As a rule of thumb, species at the top of the food chain contain more mercury than species lower down. However, there is wide inter and intra-species variability, and even fish of one species of the same size caught in the same area can have mercury concentrations that vary several fold.

For perspective, the current U.S. Food and Drug Administration (FDA) tolerance level for mercury in edible fish flesh is 1.0 ppm, which is a recent increase from a previous standard of 0.5 ppm. The 1.0 ppm level was established by the FDA with a margin of safety to protect human health. Generally speaking, DEP has decided that the FDA standard provides a useful yardstick to determine when levels of contamination may be approaching unsafe levels not only in edible fish but in other species as well.

The first report to suggest that aquatic organisms trapped in and around Berry's Creek might be contaminated with unsafe levels of mercury was contained in a confidential memorandum sent to DEP by JMA in February 1977. In samples collected by JMA the previous fall, 8 out of 14 fish exceeded the then-existing FDA action level of 0.5 ppm. Although DEP was prepared to act if this data was confirmed (for example, by banning fishing in the Hackensack River or by issuing an advisory on the need to limit the consumption of certain species to one meal a week), subsequent sampling failed to confirm the high levels reported by JMA. More specifically, of 18 fish, muskrats, and pheasants collected by DEP in 1977, none were in excess of 0.5 ppm.

Further analysis of biological organisms collected from the Meadowlands and elsewhere confirm DEP's 1977 findings, specifically, that while the aquatic and terrestrial organisms trapped in this region contain slightly above-average levels of mercury, they are not in excess of the FDA 1.0 ppm standard. However, for some species the levels are sufficiently high to merit continued surveillance, so that any changes in mercury in levels can be detected early enough for suitable action to protect the public.

Date concerning the concentration of mercury in aquatic organisms has been generated by three studies funded by DEP. The field work for the first, which concentrates on samples collected entirely from different biozones in the Meadowlands District, was completed by HMDC in October 1978, final laboratory results were submitted to DEP several weeks later. The second study, which is still ongoing, is an effort by the N.J. Marine Sciences Consortium (NJMSC) to determine the level of heavy metal contamination in aquatic organisms collected from 41 different sites in New Jersey including the Meadowlands District, with collections made 10 times during the year. The third study consists of a sampling program for aquatic fauna during three seasonal periods over 1979 and 1980. A total of twelve sampling sites were established, eight of which are in the vicinity of Berry's Creek (see Figure 14). The study was conducted by NJMSC and like the two previous studies, emphasis was placed on sampling fish species consumed by man. However, in the region of greatest mercury contamination - Berry's Creek - the water quality is generally poor due not to mercury but other causes, resulting in a highly impoverished aquatic community. The only resident and abundant fish found in this region are killfish (a common type of minnow). While these organisms are not consumed by man and are far down in the food chain, they are a useful indicator of relative contamination in that they can both be trapped easily and also spend most of their lives swimming within the same area. Thus, mercury present in killfish can be attributed to conditions at the sampling site and not, as is the case with migratory fish such as bluefish or striped bass, from levels that might have been picked up elsewhere.

The data collected by HMDC are summarized in Table 7. The average concentration of mercury in all species in the Meadowlands, including such edible species as carp, blue claw crabs, and white perch was below 1.0 ppm. Killfish collected downstream from Berry's Creek tidegate had greater concentrations of mercury than those collected upstream of the tidegate. Surprisingly, the highest mercury levels, though still low, were not detected in Berry's Creek but in Windy Ditch and in Sawmill Creek. This latter region is a wildlife refuge, with acceptable water quality and with no presently known man-related source of mercury contamination other than the mercury flowing in from Berry's Creek. The mercury concentrations in the white perch trapped in the Meadowlands, although below 1.0 ppm, are sufficiently high that additional sampling of this species is justified. Fish trapped outside the Meadowlands District at a Jersey City power plant had higher concentrations of mercury than those in the Berry's Creek basin.

The data collected by the NJMSC in 1978 are essentially consistant with HMDC's data. Table 8 lists the data collected in the area from Overpeck Creek south to Sawmill Creek. Again, mercury concentrations were within acceptable limits. Among the killifish samples, those collected near the tidegate had the highest concentrations of mercury. Killifish trapped in Sawmill Creek had concentrations of mercury averaging 0.42 ppm. In a species of fish such as killifish, this level of mercury suggests that a source of contamination is present. However, it should be noted that there are several locations elsewhere in the State where there is no known major source of mercury pollution, but where the mercury burden in individual killifish is on the same order.

Another source of information regarding the levels of mercury in fish comes from a special killifish sampling effort conducted at DEP's request by the NJMSC in July 1978. Killifish from 9 locations on Berry's Creek (see map) were collected, grouped according to size, and analyzed for mercury (Figure 13). At all 9 stations, the mercury concentrations ranged from 0.13-0.21 ppm, which is a level found in many other parts of the State (Table 9). There was no discernable difference when killifish were compared by size class or by proximity to the Ventron site. These data suggest that factors other than the total amount of contaminated water and sediment are important determinants in the mercury content of fish in any area.

The data from the 1979-80 seasonal sampling program conducted by NJMSC are presented in Table 9 and 10. In all cases mercury concentrations in the fauna met the federal standard of 1 ppm except for 6 killifish samples. Mercury concentrations in killifish were generally highest as one approaches the tidegate and there levels were slightly higher than those previously reported. Because of the nature of the sampling sites, it is very difficult to analyze the remaining information about edible fauna in the Berry's Creek area. The highest mercury concentration in a fish species other than killifish was found in an alewife (0.72 ppm) caught at the mouth of Sawmill Creek, whereas the highest blue crab level as 0.68 ppm found at sampling site G.

A NJMSC investigation of heavy metal contamination in aquatic organisms from a wide variety of rivers and creeks in New Jersey has not been completed and the data listed in Table 8 cover only a small section of the entire study area. Because the larger volume of data has not yet been assessed or analyzed, a summary of the broader results has not been included in this report but preliminary indications suggest that several other bodies of water contain fish the same or higher concentrations of mercury than the fish in Berry's Creek. However, the average values at all locations are less than 1.0 ppm.

From a human health perspective, the data regarding mercury contamination in fish in the Hackensack Meadowlands aquatic ecosystem are the most important since the consumption of these fish would provide the primary mechanism for mercury to enter the human body. Presently, average mercury levels are within currently accepted levels. For some species such as white perch, the levels are sufficiently high to warrant further surveillance. The fact that higher levels of mercury are sometimes found in fish trapped in areas of low contamination, than the Berry's Creek ecosystem suggests that factors other than total amount of mercury in the water and sediment are important determinants of mercury burdens in fish. Since water quality conditions in Berry's Creek are expected to change within the near future due to the construction of additional sewerage treatment systems, and because such changes may alter the amount of mercury being detected in fish, the aquatic biota in this area will have to be monitored very closely for years to come.

HMDC, in addition to analyzing finfish and shellfish, has collected birds, mammals, reptiles, amphibians, and vegetation for mercury analysis. Of 35 birds trapped in the Meadowlands, only one had a mercury concentration in excess of 1.0 ppm in the muscle tissue. The average concentration in this collection (which included gulls, ducks, owls, egrets, etc.) was 0.36 ppm. The range of concentration was 0.059-1.2 ppm. Interpreting this data for birds is complicated because many bird species migrate over a large range of areas, both seasonally and in search of food near each temporary home. Generally, the scientific literature shows that fish-eating birds, such as herons, have higher mercury levels than plant and seed eaters, such as ducks. This appears to be the case in the Meadowlands, however, the sample collection is insufficient in size to make this assertion with total confidence.

Terrestrial species had significantly lower mercury concentrations than fish species. Several muskrats have been trapped in this region by HMDC and JMA, with mercury concentrations in flesh less than 0.02 ppm. In 35 other mammals trapped in the area (including rats, mice, rabbits, etc.), only 4 specimens exceeded 0.1 ppm; the highest value was 0.22 ppm.

The literature regarding the uptake and levels of mercury in marsh vegetation is scarce. Some papers have been published which suggest that marsh plants can be a potential source of uptake of mercury from soils to the food web. Two important marsh plants, phragmites and spartina, were examined in the fall of 1977 and the Spring of 1978 by HMDC. The sampling locations are shown in Figure 15. Four different plant tissues were analyzed: the rhizome, stem, leaf, and fruit structure. As shown in the graphs in Figure 16, only slight differences were observed from the average mercury concentration in plant tissues, whether the plants were collected from areas of heavy mercury soil contamination or light contamination. The mercury content in the rhizomes (root tissue) were higher in the plants collected from Berry's Creek tidal marshes.

4. <u>The Potential for Unacceptable Health Risks to Humans</u>

It is clear from the data that mercury has contaminated the physical environment surrounding the Berry's Creek ecosystem. Further, above-average levels have been detected in aquatic biota; however, they have not yet reached unacceptable levels.

Because of the large amounts of mercury in the soils and sediments of Berry's Creek, and because under complex and not fully understood conditions, this mercury, even if present as organic mercury, can become methylated, it is the Department's position that this mercury contaminated site is an "ecological time bomb." That is, increased rates of methylation may occur at the site in the future and result in a rapid uptake of mercury by fish to unsafe levels. Even with the completion of DEP's proposed cleanup and abatement program (see below), there will be substantial amounts of mercury remaining in the ecosystem. Thus, there is the potential for future unacceptable health risks to humans via the consumption of contaminated finfish and shellfish. The risk will be minimized by the continued monitoring of aquatic organisms which DEP will conduct now and into the forseeable future.

Because the Velsicol/Wolf site is currently undeveloped, the potential risk of human contamination from groundwater or contaminated soils is believed minimal. Exposure to unsafe levels of mercury vapor in surrounding residences is also thought to be improbable by both DEP and the Department of Health. Nonetheless, in order to be sure, blood, hair, and urine samples were collected for mercury analysis by the Health Department from over 300 individuals in nearby residences and businesses. The results of these tests, announced on April 26, 1979, indicate that there is no acute health hazard to the population residing in the area from the mercury contamination in the vicinity of the Velsicol/Wolf properties that excessive uptake of mercury has not occurred. Only low levels of mercury typical of the U.S. population at large were detected in the blood and urine samples (hair has not been analyzed at this time). For example, it can be expected that less than 10 pbb of mercury can be found in the average persons blood, but levels as high as 30 ppb can be found in up to 5% of the general U.S. population. Ninety percent of the tested individuals from the Wood-Ridge, N.J. area had blood mercury levels below 10 ppb with the highest level only 15 ppb. Similarly, with the exception of four individuals the levels of mercury found in urine samples were well within an acceptable and non-hazardous range. These aforementioned individuals are all members of the same family in which a bottle of metallic mercury, brought home by youngsters from a high school laboratory as a plaything, may well have been the major source of exposure.

However, within this general range of acceptable and non-hazardous low levels of mercury detected in the urine samples, the Health Department was able to ascertain that residents who have frequent exposure to the contaminated property have slightly higher urine mercury levels than residents with no exposure to the site. DEP ordered a program to fence off the property and Velsicol complied in June 1979.

With the enactment of our proposed plans for cleanup, containment, and entombment of the Velsicol property, and with continued biological monitoring, DEP believes that we can insure the protection of human health in this area. If monitoring indicates increased levels of mercury in fish or unacceptable levels in air, DEP is prepared to take whatever action the information calls for.

V. CONCLUSION

In conclusion, the Department of Environmental Protection has determined that the physical environment in the vicinity of the old Wood Ridge Chemical Corporation is heavily contaminated with mercury. Excessive levels of mercury can be found in water, soils, and sediments on and adjacent to the Velsicol/Wolf properties. It has further been determined that a zone of heavy mercury contamination extends southward among the marshes, soils, sediments, and surface water adjacent to Berry's Creek as far downstream as the Route 3 bridge. Other areas of the Hackensack Meadowlands also have above average mercury concentrations, as does the air above the site in question.

Despite the heavy contamination in the Berry's Creek ecosystem, the aquatic organisms continue to be within acceptable federal standards for mercury contamination. Organisms with higher levels than found in Berry's Creek can be found in areas of lesser or no known mercury contamination. Because of the chemical, physical, and biological properties of mercury, it is the Department's position that mercury levels in aquatic organisms might rise rapidly in the future should water quality conditions in Berry's Creek change. It was DEP's position in a court suit that steps should be taken by the past and present landowners to remove, abate, and entomb as much of the mercury contaminated soils and sediments as is feasible to prevent future mobilization. Such action would help reduce the possibility of high concentrations of mercury being found in aquatic organisms or elsewhere in the future.

On August 27, 1979, the decision was handed down in State of New Jersey v. Ventron, et al. (See Appendix I for the judge's ruling.)

APPENDIX 1 - Judge Lester's Opinion, pp. 63-68

REMEDY

Much of the difficulty heretofore was the result of lack of assurance on the part of the State as to the steps to be taken. It is not sufficient (nor logical) for the State to order defendant to abate a nuisance or cleanup a polluted area where the parties differ as to what must be done. The State apparently does not want to take the responsibility of living with its own choice. The State's position has been to say to defendants, in effect - you clean it up and when you're done you will be responsible to see that you've accomplished a result. In essence, the State seeks a judgement requiring the defendants to bear the burden of cleanup as well as the responsibility for subsequent expenses should the measures taken prove inadequate.

This court will not permit the State to assert such a position. The State must take the lead. The Court will order the State to act. The clean up of Berry's Creek will proceed. The rational and logical approach is that the Berry's Creek clean up cost, be by dredging or otherwise, be borne initially and equally by Velsicol and Ventron. They are severally liable. They acted separately and independently. In such case there is no joint liability. 74 Am Jur 2d § 63 (1971). The State is to prepare and present a plan for clean up within 60 days after judgement is entered. The liable defendants will have 30 days thereafter to serve and file reply papers as to the viability of that plan. Thereafter the Court will, after argument, finalize the plan. No plenary hearing will be required.

Velsicol similarly will, within 60 days from judgement, present a plan for surfacing or blacktopping the Velsicol tract to prevent surface water runoff. That responsibility must be Velsicol's. The plan may be, in whole or in part, part of a general development approach. It shall include a timetable and cost estimates. Here the State will have 30 days to comment on the efficacy of the proposed plan and here again the Court will rule after argument.

The Court will not now require entombment of the entire Velsicol tract. The preponderance of the evidence does not demonstrate that there is present leaching of groundwater, nor is there proof that such leaching would create in a dredged Berry's Creek a hazardous condition.

This Court must eventually determine if the combination of the existing Wolf containment system, the dredged Berry's Creek and the surfacing of the Velsicol property suffice to control the situation in the future. Is there such groundwater leaching into Berry's Creek as would violate the standards now existant and create a hazardous condition requiring futher action at the expense of the liable defendants by way of entombment or otherwise?

When the surfacing of the Velsicol property and the clean up of Berry's Creek are completed, the monitoring may begin, to see if mercury is leaching into the creek and in what amount. If leaching is taking place now, it has been taking place during all these years and one year of checking after the clean up of Berry's

Creek and the surfacing of the Velsicol land will suffice to make the determinations required. The State may, during that year monitor as it deems appropriate to determine the efficiency of the surface cover and the amount of leaching then occuring and provide proof of its claim that a further remedy by way of entombment of the entire tract is otherwise required.

The cost of monitoring, however, must be initially borne by the State. The State has heretofore failed to prove its case as to present leaching. If it seeks to prove such leaching, the burden is upon it: The State or the Fund will initially serve as the source of financing such monitoring.

N.J.S.A. 58:10-23.11 o (3) provides that monies in the Spill Compensation Fund be disbursed

> "...as may be necessary for research on the prevention and effects of spills of hazardous substances on the Marine environment and the development of improved cleanup and removal operations as may be appropriate by the Legislature; provided, however, that such sum shall not exceed the amount of interest which is credited to the fund."

The oil companies argue that monitoring may not be paid for from Fund monies as monitoring is (1) not "research" and (2) there has been no appropriation. They also argue that any sums could not exceed the amount of interest which is credited to the Fund which would undoubtedly not cover monitoring costs.

However, the Court views monitoring costs as being separate and apart from N.J.S.A. 58:10-23.11 o (3). Monitoring in the situation before the Court is part and parcel of the abatement of spills and discharges as to which the State must act and for which the Fund is strictly liable. The State and/or the Fund must initially bear this burden.

If, in fact, the Court determines that there is leaching which will create a violation of the standards now existant, the liable defendants may be charged with all or part of the monitoring costs.

But there must be a limit to ultimate liability and the Court intends to now set that limit within the framework of all of the proof before it.

Ventron is liable to Wolf/Rovic. Velsicol must surface its land; the liable defendants must cover the costs of cleaning up Berry's Creek. These amounts may be determined with some specificity now, and judgements will serve as the remedy afforded. How then, to provide security if the necessity of further action is shown? - i.e., the costs of entombment and/or monitoring?

As security for entombment and/or monitoring costs, and as a condition to release from further liability and as a condition to release of the Velsicol land from any liens or restrictions on transfer, Ventron and Velsicol will be required to post security to assure payment for any procedures which may prove to be necessary should the monitoring system indicate that there is present actionable leaching or leakage which is reaching or may reach Berry's Creek.

The bond or cash security required from Ventron and Velsicol will be determined within the next few weeks after the Court re-examines the initial damage claim of the State, and adjusts that sum considering (a) this opinion, (b) the Wolf containment system cost, (c) the fact that Berry's Creek will be dredged at the expense of defendants, (d) the fact that Wolf land is now surfaced (or will be surfaced), (e) the fact that Velsicol will, at its own expense, surface (or develop so as to prevent polluted surface water reaching Berry's Creek) its 33 acres and (f) any suggestions by the attorneys for the State, Velsicol and Ventron based upon proof before me. As the Court views the present posture of the case the maximum liability, if any, that might be imposed on Velsicol and Ventron could be $1,000,000 each.

The limits of liability of the liable defendants having thus been determined, this is now principally a mattter of the protection of the public by the State.

The State is not merely an innocent party. The DEP could have and should have closed down the plant as early as 1968. Its inaction in the years subsequent to 1968 must relive the liable defendants of some of the burden and responsibility. Yet, in so doing, the public must be protected.

The clean up of Berry's Creek, the surfacing of the Velsicol tract, the monitoring and possible, future entombment, together with the escrowed monies will provide the necessary protection. Beyond that, the Legislative Scheme mandates that the Spill Compensation Fund be utilized to protect the environment and the public.

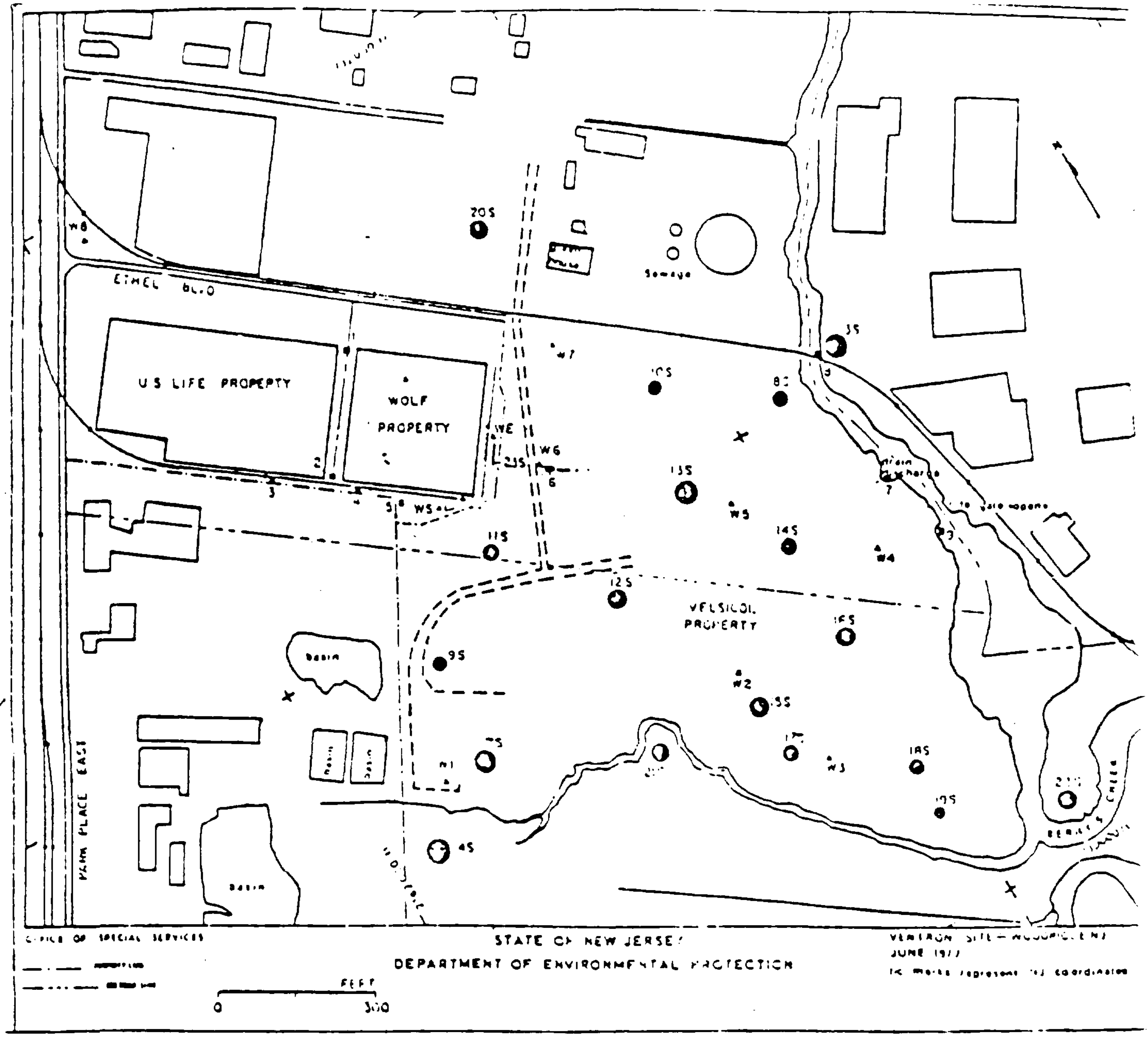
If at the end of the year of monitoring, no present leaching is reaching Berry's Creek in such amounts as would violate present standards and create a dangerous situation, Velsicol and Ventron will be entitled unconditionally to the return of the escrow monies and/or the release of sureties.

In the final analysis, the State is getting more in terms of dollars than it proposed initially. The costs of the clean up and surfacing together with the monies in escrow undoubtedly exceed $4,000,000. The State's estimated costs of <u>all actual</u> procedures was less than this - approximately $3,000,000. This result is not unfair.

The public must be protected. The State is meeting its obligation to provide for the health, safety and welfare of the people of this State. It will take the corrective steps required at the expense of the liable defendants. It will monitor at the initial expense of the Spill Fund. It will correct such hazards as the monitoring exposes and correct them at the expense of the liable defendants.

The Court retains jurisdiction to effectuate the purposes and intent of this opinion. If Wolf/Rovic and Ventron cannot agree on the quantum of damages, the Court will set the ground rules for the determination of the same.

Submit an appropriate form of final judgement.



Soil Station

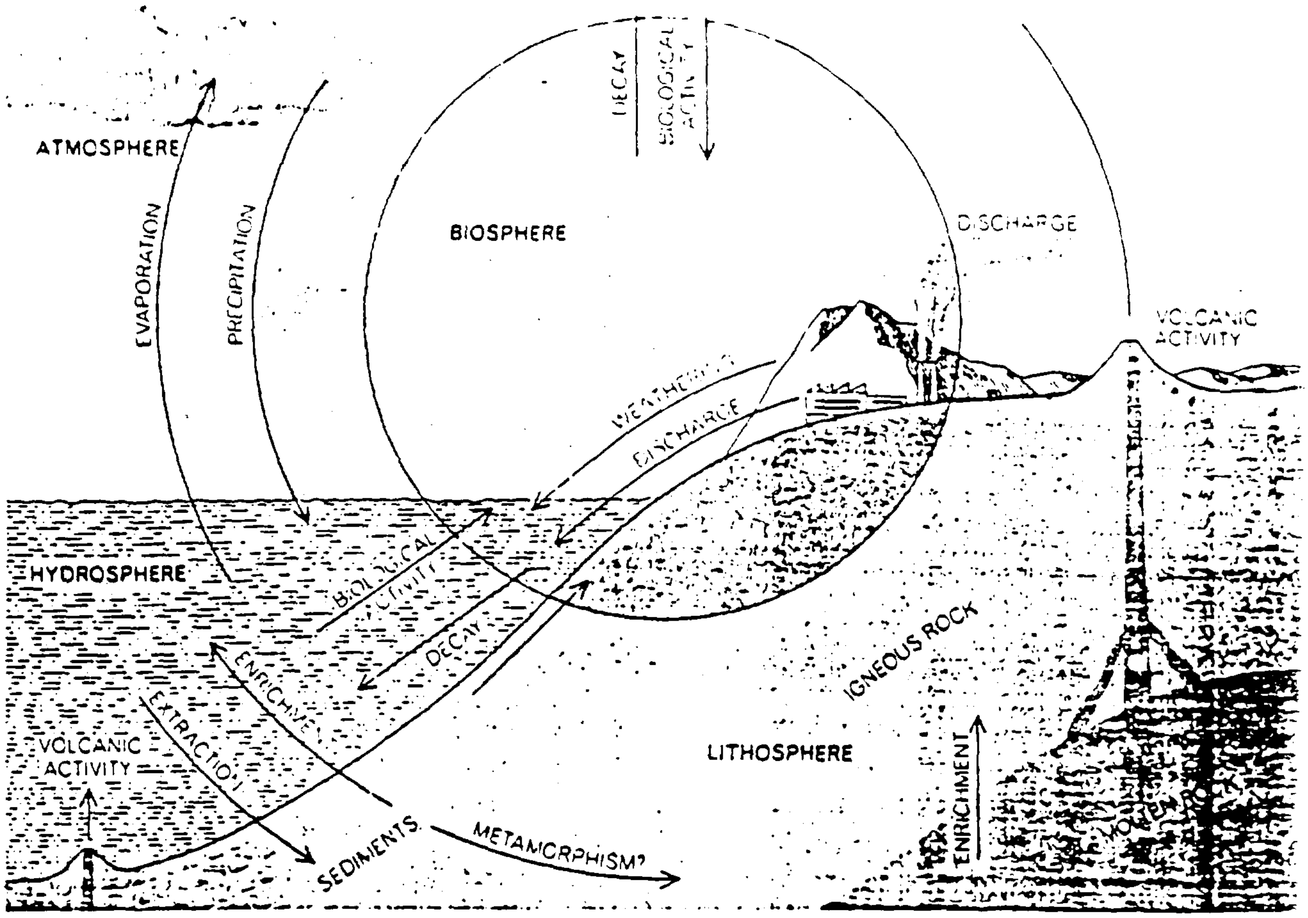
▲ Observation Well

■ Surface Water Station

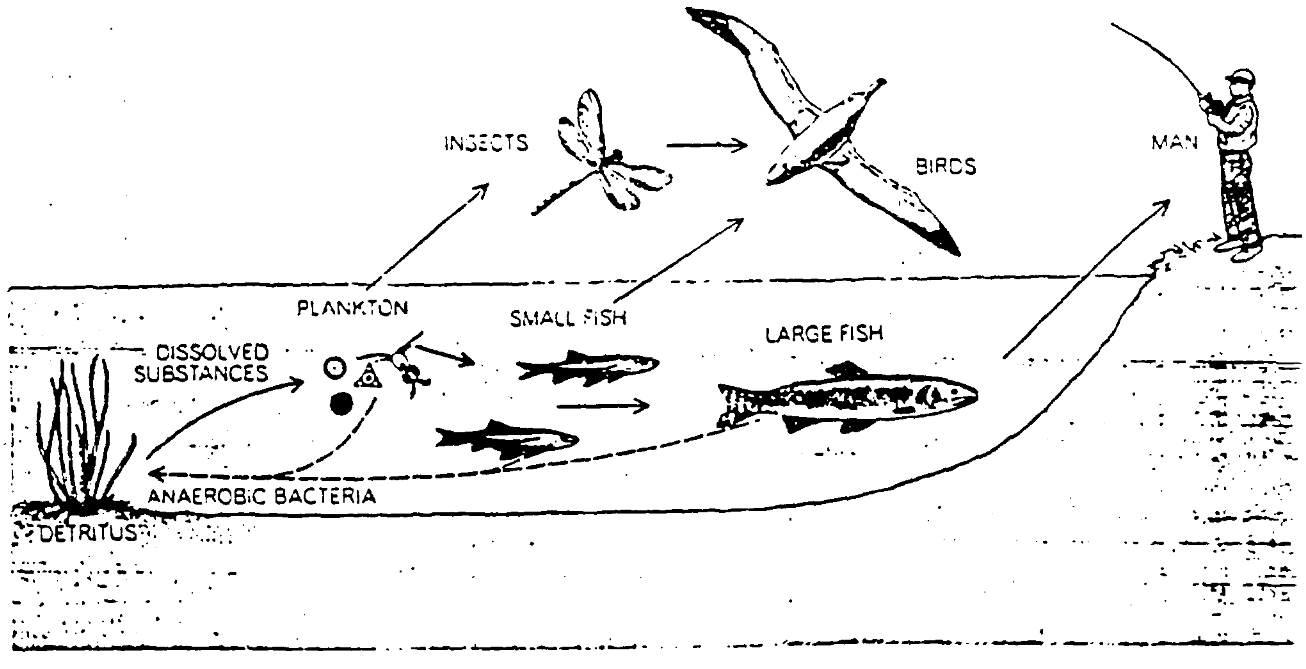
Figure 1. Locations of surface water stations, observation wells, and soil stations on and near the subject site from JMA Report.

823950028

25-A



MERCURY CYCLE disperses the metal through the lithosphere, hydrosphere and atmosphere and through the biosphere, which interpenetrates all three. Mercury is present in all spheres in trace amounts, but it tends to be concentrated by biological proce- Man's activities, in particular certain industrial processes, n now present a threat by significantly redistributing the me

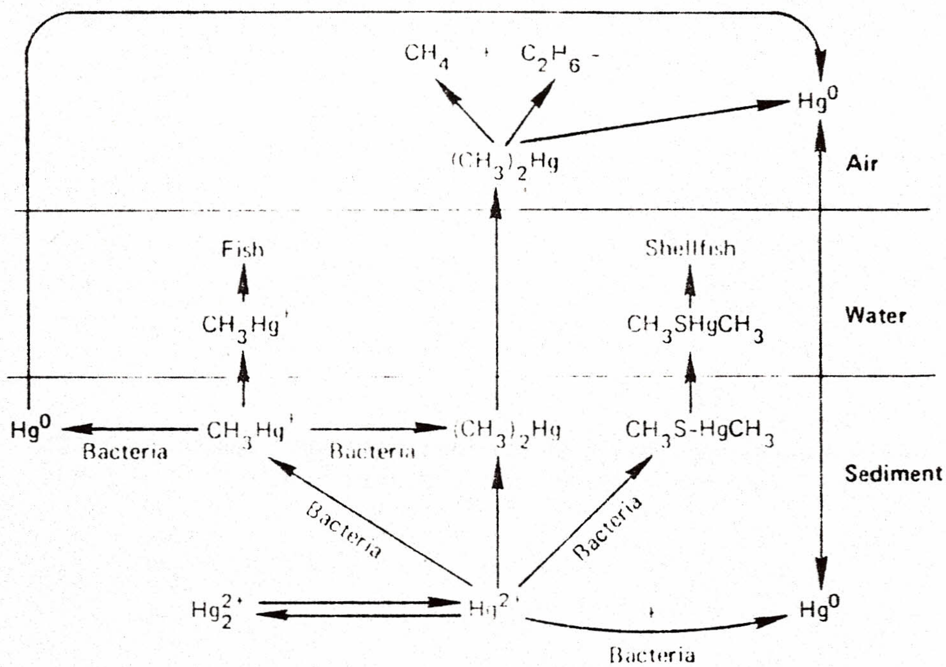


AQUATIC FOOD CHAIN is a primary mechanism by which mercury is concentrated. At each trophic level less mercury is excreted than ingested, so that there is proportionately more mercury in algae than in the water they live in, more still in fish that fe the algae and so on. Bacteria and the decay chain *(broken ar- promote conversion of any mercury present into methyl me-*

Fig. 2---From Scientific American, Mercury in the Environment by Leonard Goldwate

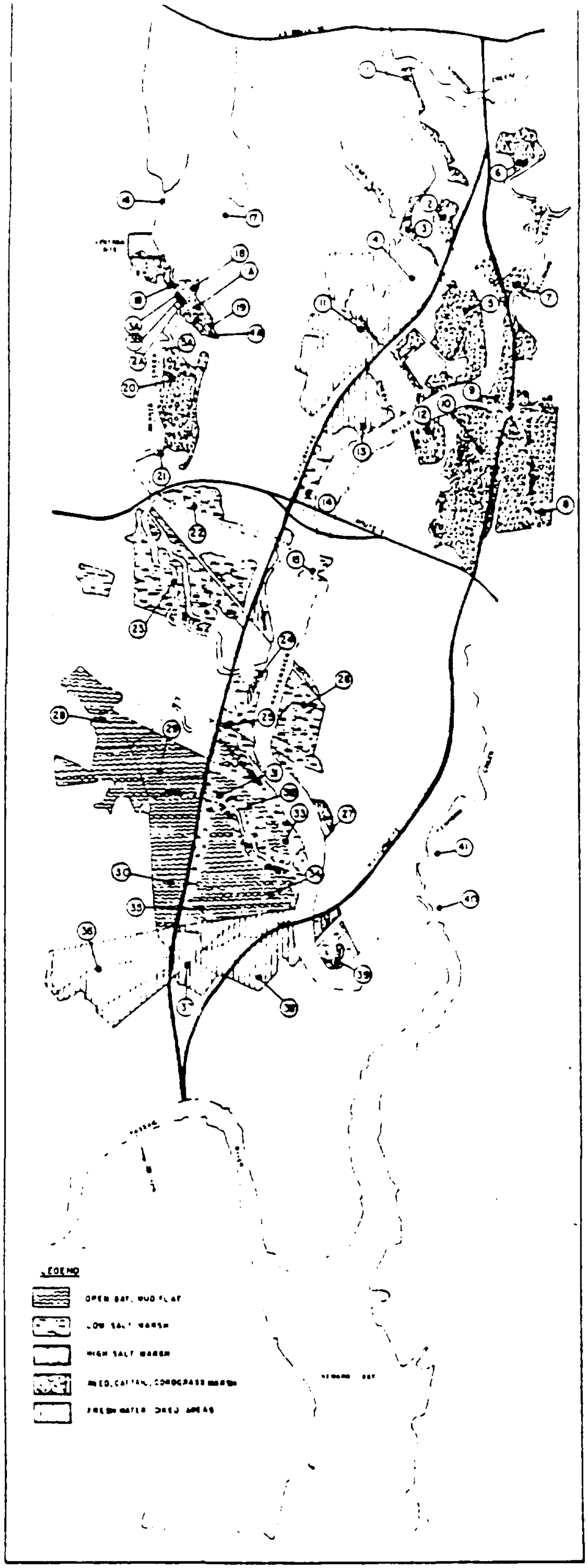
Figure 3 The Mercury Cycle Demonstrating the Bioaccumulation of Mercury In Fish and Shellfish

823950030



SOURCE: Modified from Wood (1974). Science 183:1049-1052. Copyright 1974 by the American Association for the Advancement of Science.

Fig. 4---Marsh Soil and Channel Sediment Sampling Sites. From HMDC Report (Note: Ventron site is located near upper left corner).


LEGEND
OPEN BAY, MUD FLAT
LOW SALT MARSH
HIGH SALT MARSH
REED, CATTAIL, CORDGRASS MARSH

823950031

Fig. 5---Peak Mercury Concentration in Marsh Soil Core Samples.

This figure illustrates the peak mercury concentration detected within an HMDC marsh soil core sample for any depth of core. Closed circles indicate a peak concentration greater then 1000 ppm; half circles between 100-1000 ppm; and open circles less then 100 ppm.

823950032

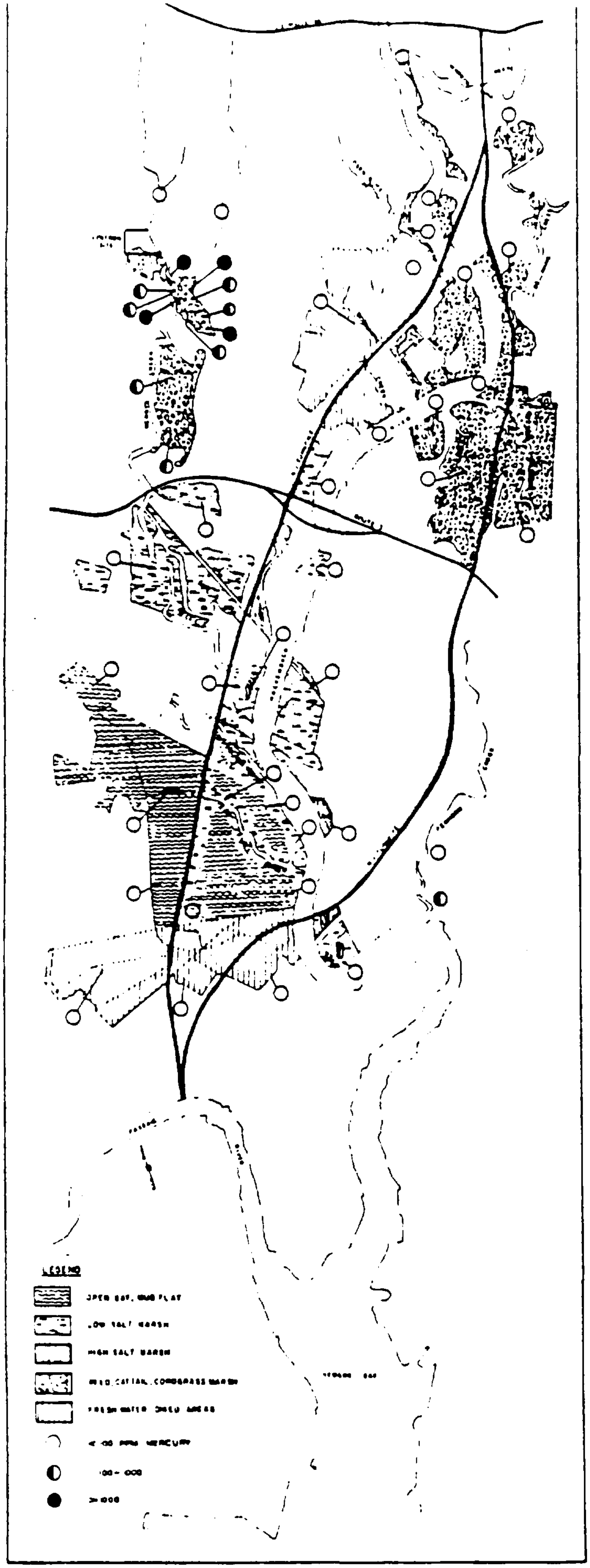

LEGEND
OPEN BAY, MUD FLAT
LOW SALT MARSH
HIGH SALT MARSH
MERCURY

Fig. 6

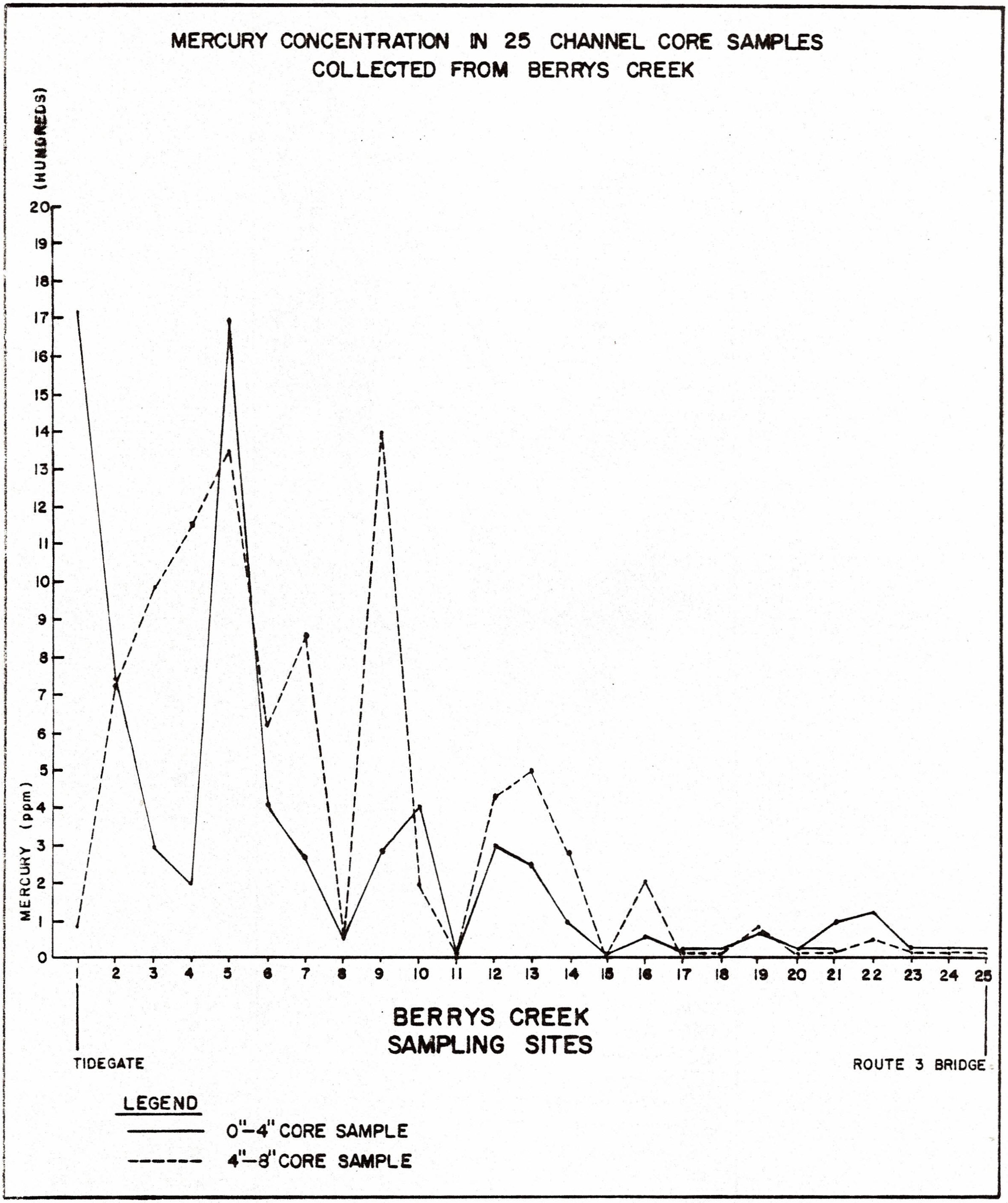
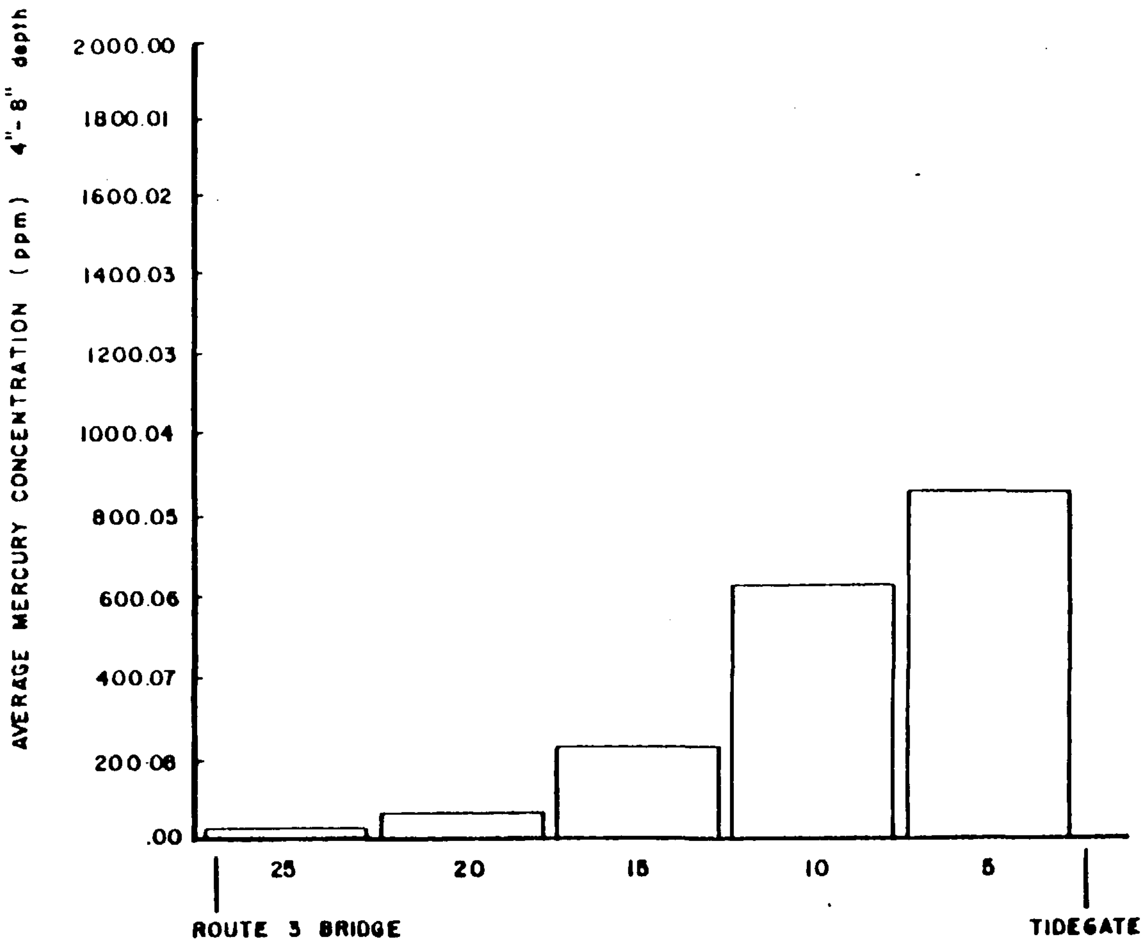

MERCURY CONCENTRATION IN 25 CHANNEL CORE SAMPLES
COLLECTED FROM BERRYS CREEK
MERCURY (ppm) (HUNDREDS)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
BERRYS CREEK
SAMPLING SITES
TIDEGATE
ROUTE 3 BRIDGE
LEGEND
0"–4" CORE SAMPLE
4"–8" CORE SAMPLE

Fig. 7---Average mercury concentration in 25 channel sediment core samples collected from Berrys Creek

Mercury concentrations at 4"-8" depths in 25 channel sediment core samples (for raw data-see Fig. 6) were averaged for every 5 consecutive stations. The results were graphed according to the upper limit of the sampling site number (e.g. 5 represents stations 1-5) versus average mercury concentrations.

823950035

AVERAGE MERCURY CONCENTRATION IN 25 CHANNEL SEDIMENT
CORE SAMPLES COLLECTED FROM BERRYS CREEK



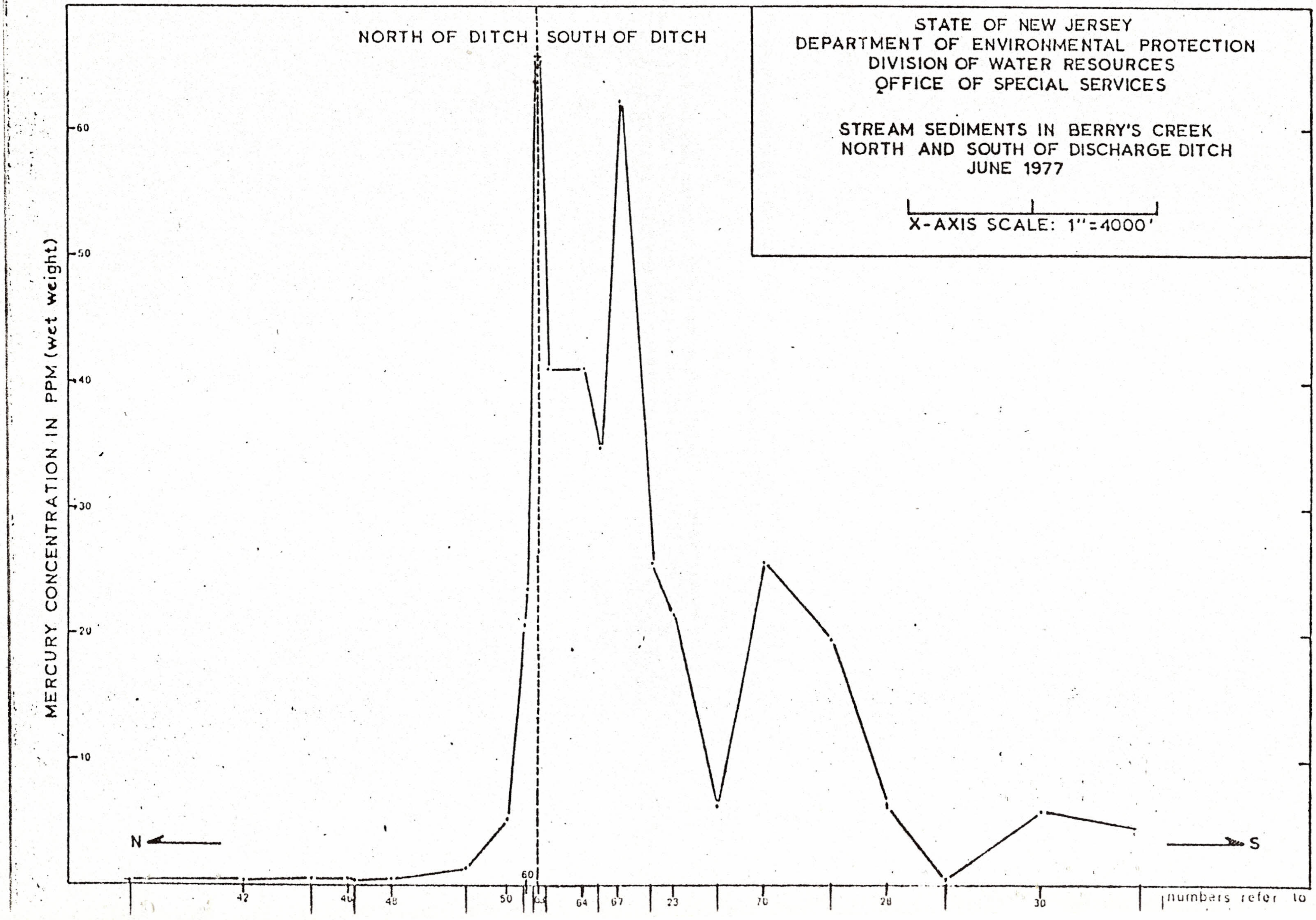
SAMPLING SITES BY
UPPER LIMIT OF
INTERVAL

82395036

32

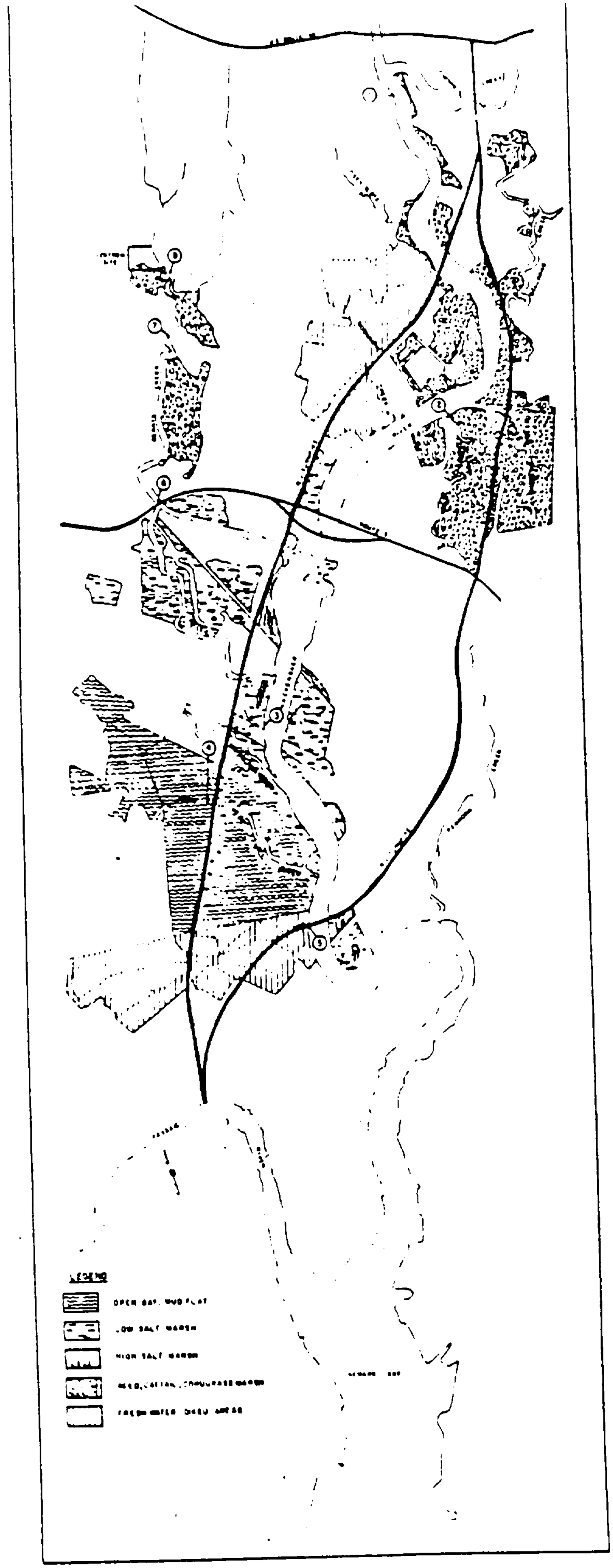
Fig. 8---Mercury Concentrations in the stream Sediments of Berrys Creek. From Hutchinson/Reed Report.

Note: The analysis of these stream sediment samples was performed on a wet weight basis. This form of analyses greatly under estimates the mercury concentration relative to the analyses of samples on a dry weight basis.



STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF WATER RESOURCES
OFFICE OF SPECIAL SERVICES
STREAM SEDIMENTS IN BERRY'S CREEK
NORTH AND SOUTH OF DISCHARGE DITCH
JUNE 1977
X-AXIS SCALE: 1"=4000'
NORTH OF DITCH
SOUTH OF DITCH
MERCURY CONCENTRATION IN PPM (wet weight)
60
50
40
30
20
10
N
S
42
46
48
50
60
64
67
23
70
28
30
numbers refer to

Fig. 9---Surface Water Sampling Sites. From HMDC Report.



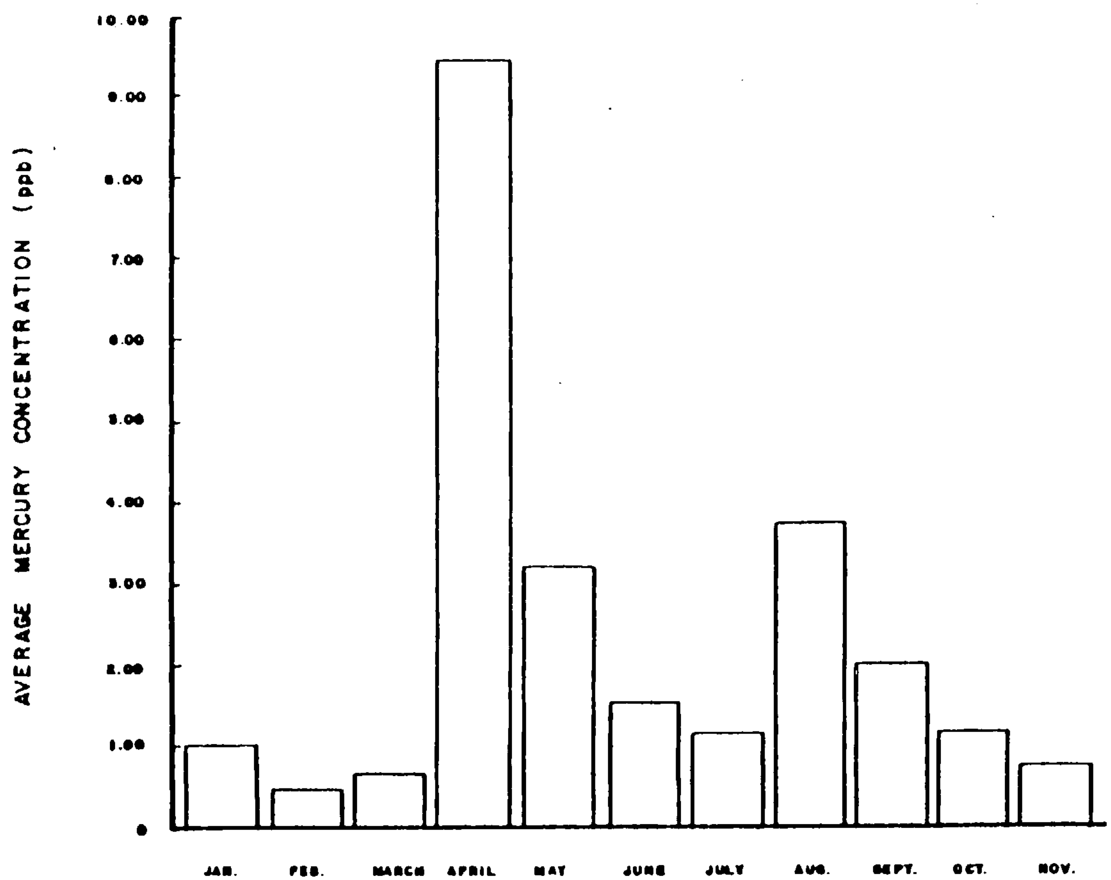
823950040

36

Fig. 10a---Mercury in Surface Waters of Berrys Creek at low tide.

This graph demonstrates average monthly mercury concentrations for sites 6-8 (see Fig. 9) on Berry Creek.

MERCURY IN SURFACE WATERS OF
BERRY'S CREEK - LOW TIDE



SAMPLING SITE 6-5 SEE FIG. 9

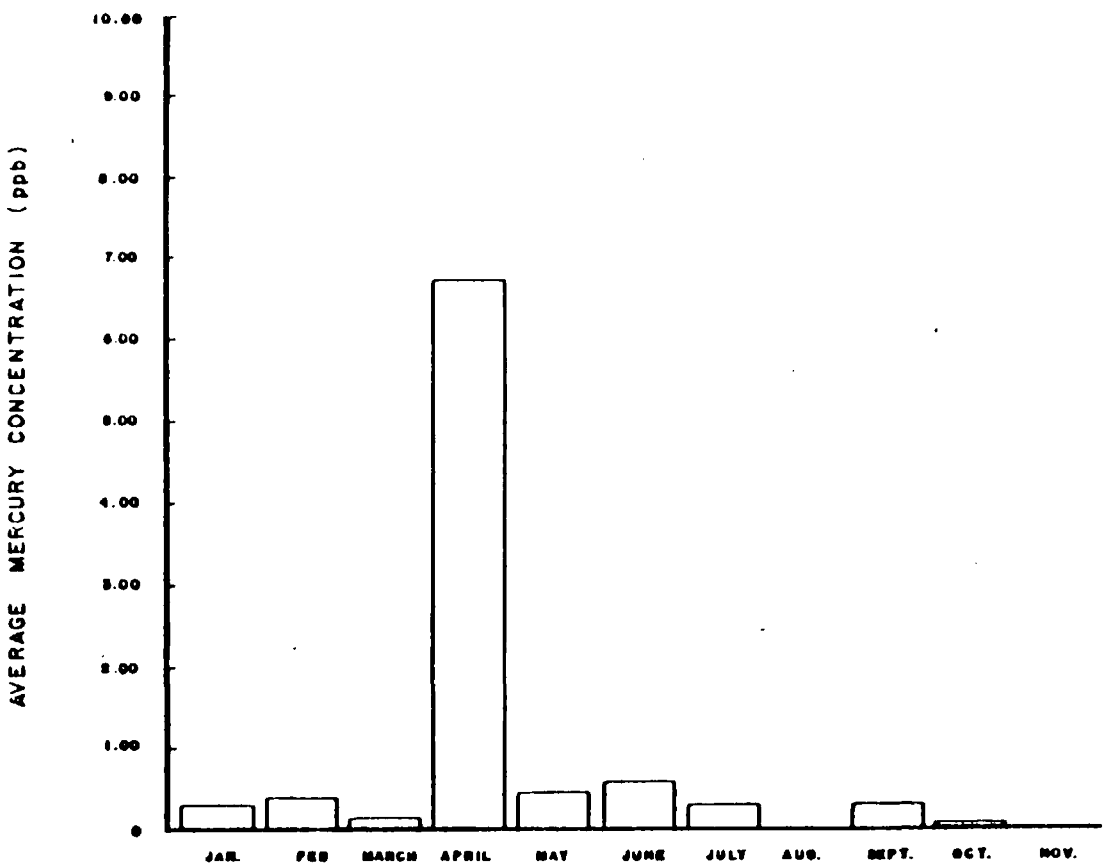
823950042

38

Fig. 10b---Mercury in Surface Waters of the Hackensack Meadowlands (excluding Berrys Creek) at low tide.

This graph demonstrates the average monthly mercury concentrations in the Meadowlands excluding Berrys Creek (Sites 1-5).

MERCURY IN SURFACE WATERS OF THE
HACKENSACK MEADOWLANDS
(EXCLUDING BERRY'S CREEK)
AT LOW TIDE



SAMPLING SITE 1-5 SEE FIG. 9

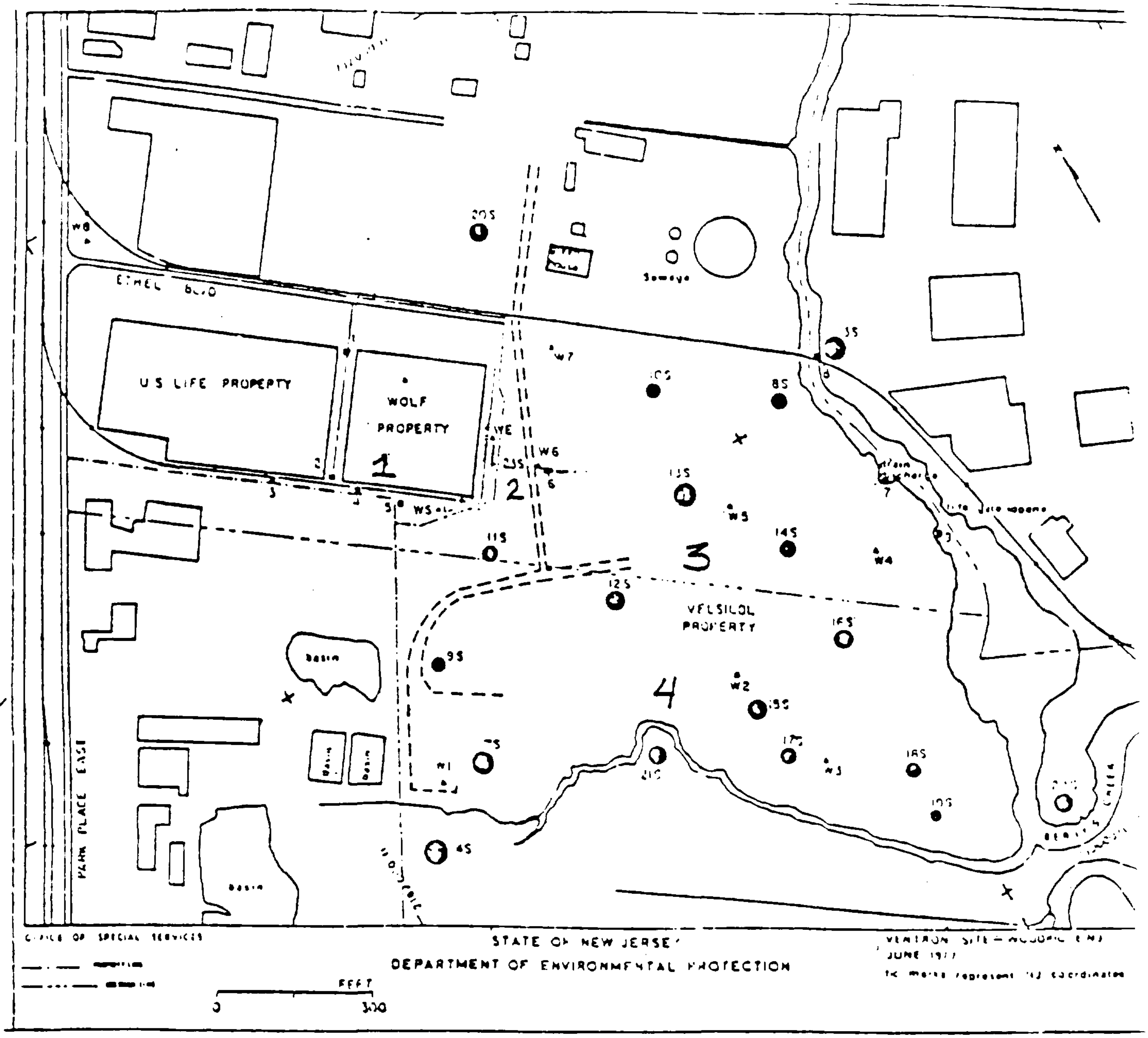
823950044

4D

FIG. 11

AIR MONITORING SITES FROM USEPA
AIR MONITORING REPORT TO DEP

823950045



● Soil Station

▲ Observation Well

■ Surface Water Station

Figure 11. Locations of surface water stations, observation wells, and soil stations on and near the subject site from JMA Report.

823950046

FIG. 12

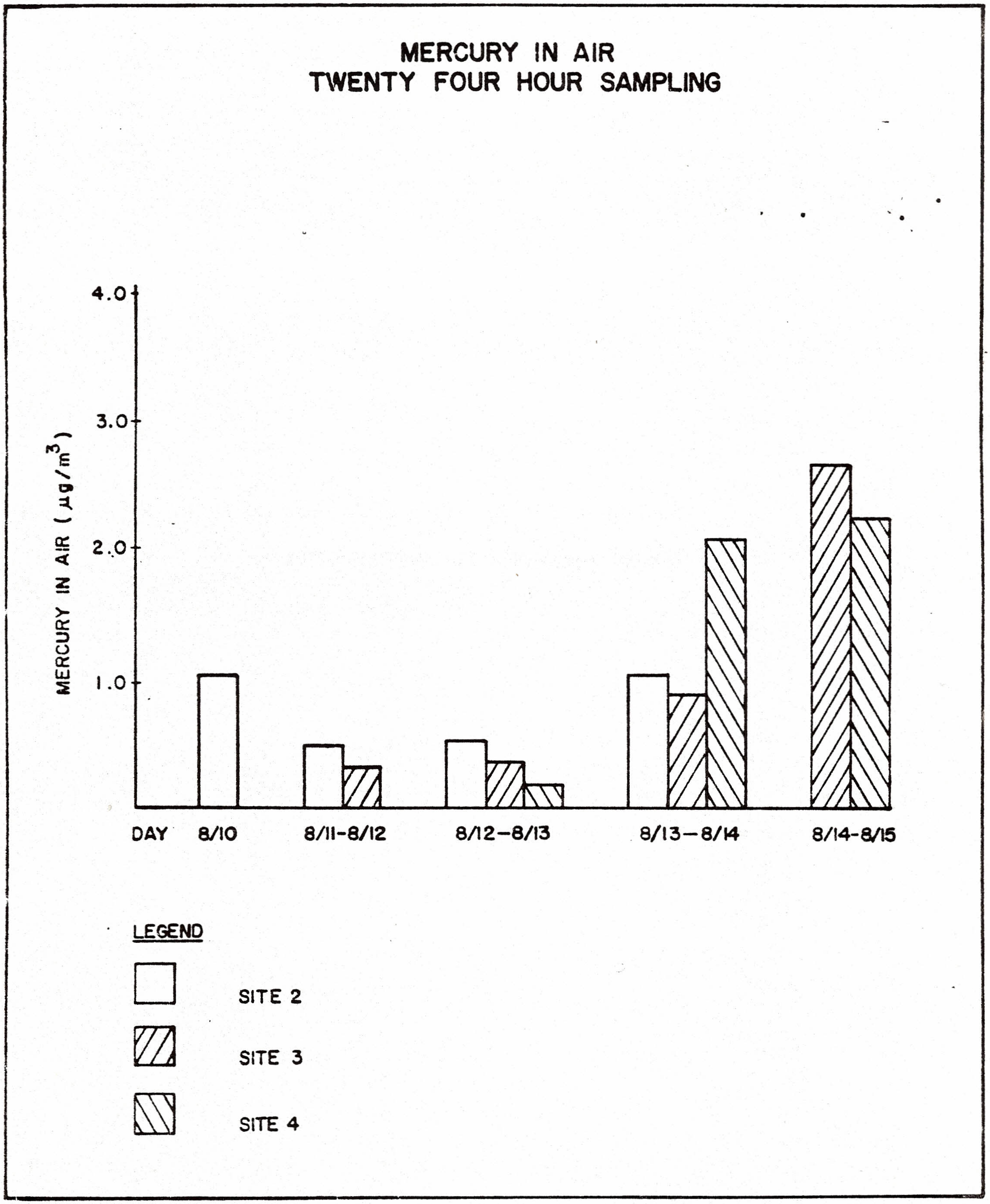
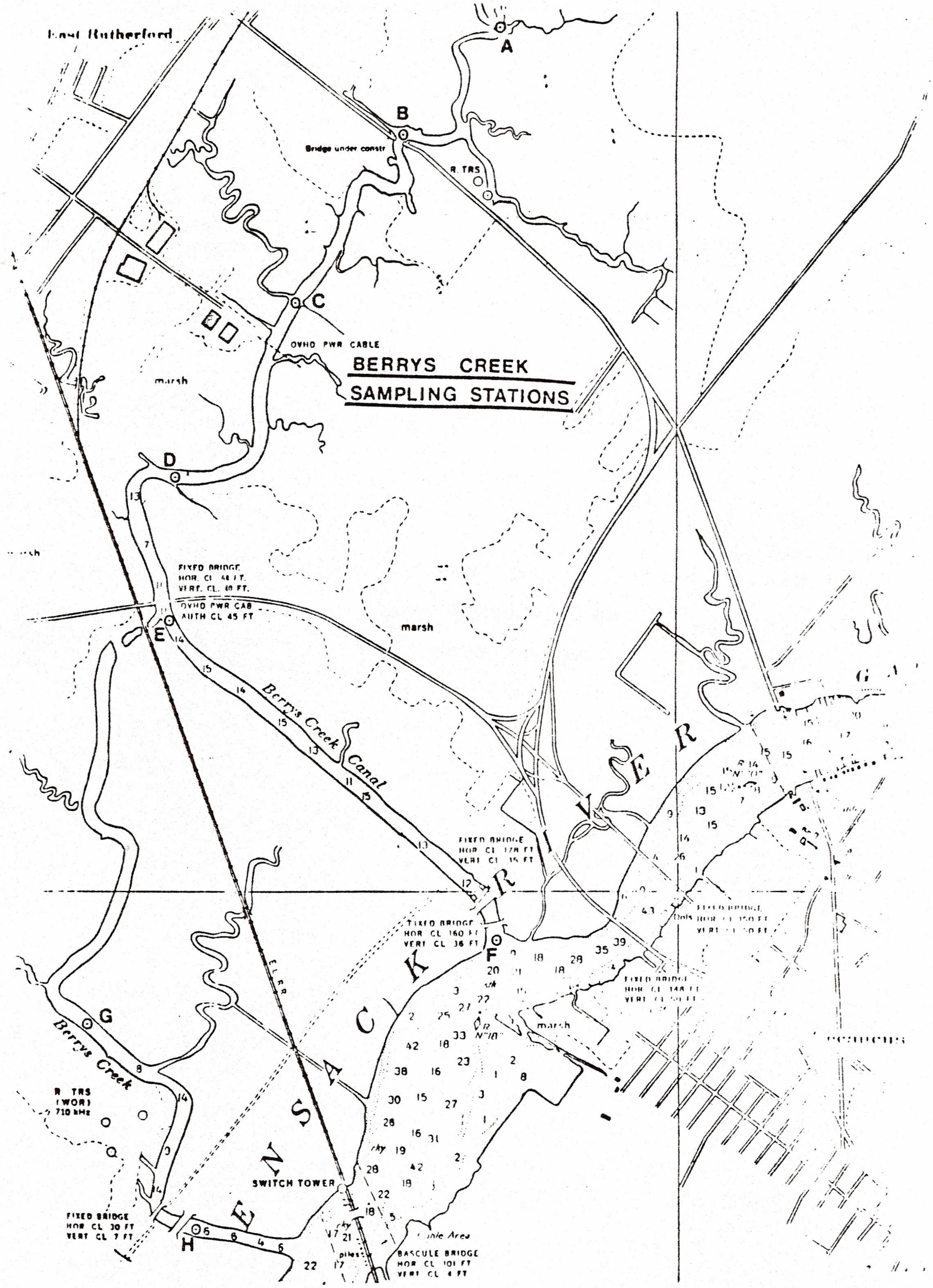

MERCURY IN AIR
TWENTY FOUR HOUR SAMPLING
4.0
3.0
2.0
1.0
MERCURY IN AIR (µg/m3)
DAY
8/10
8/11-8/12
8/12-8/13
8/13-8/14
8/14-8/15
LEGEND
SITE 2
SITE 3
SITE 4

FIG. 13

SPECIAL NJMSC KILIFISH SAMPLING SITES

SPECIAL NJMSC KILLIFISH SAMPLING SITES

Figure 14 Sampling Locations In The Vicinity of Berry's Creek
For the 1979-80 NJMSC Aquatic Fauna Monitoring Program



BERRYS CREEK
SAMPLING STATIONS
East Rutherford
A
B
Bridge under constr
R. TRS
C
OVHD PWR CABLE
marsh
D
FIXED BRIDGE
OVHD PWR CAB
AUTH CL 45 FT
E
Berrys Creek Canal
marsh
RIVER
FIXED BRIDGE
FIXED BRIDGE
HOR CL 160 FT
VERT CL 36 FT
F
HACKENSACK
marsh
G
Berrys Creek
R TRS
(WOR)
710 kHz
SWITCH TOWER
FIXED BRIDGE
HOR CL 30 FT
VERT CL 7 FT
H
BASCULE BRIDGE
HOR CL 101 FT
VERT CL 4 FT

FIG. 15

VEGETATION SAMPLING SITES

FROM HMDC REPORT

VEGETATION SAMPLING SITES

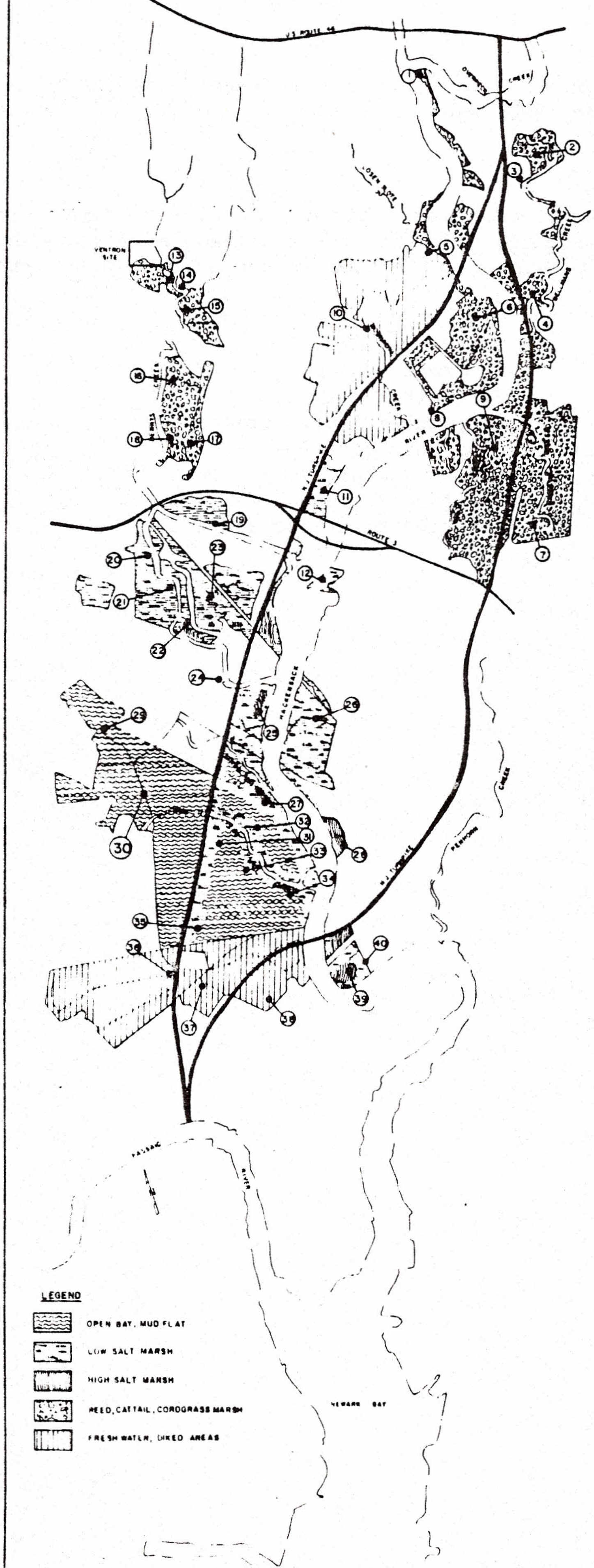


Fig. 16a - h --- Mercury Concentrations on Meadowlands Marsh Vegetations.
From HMDC Report.

4 different tissues (leaf, stem, rhizome, fruit structures) from either Spartina alterniflora or Phragmites communis were analyzed for mercury Graphs 16a-h show the amount of mercury in each plant tissue in ppm at each site. See Fig. 15 for site locations.

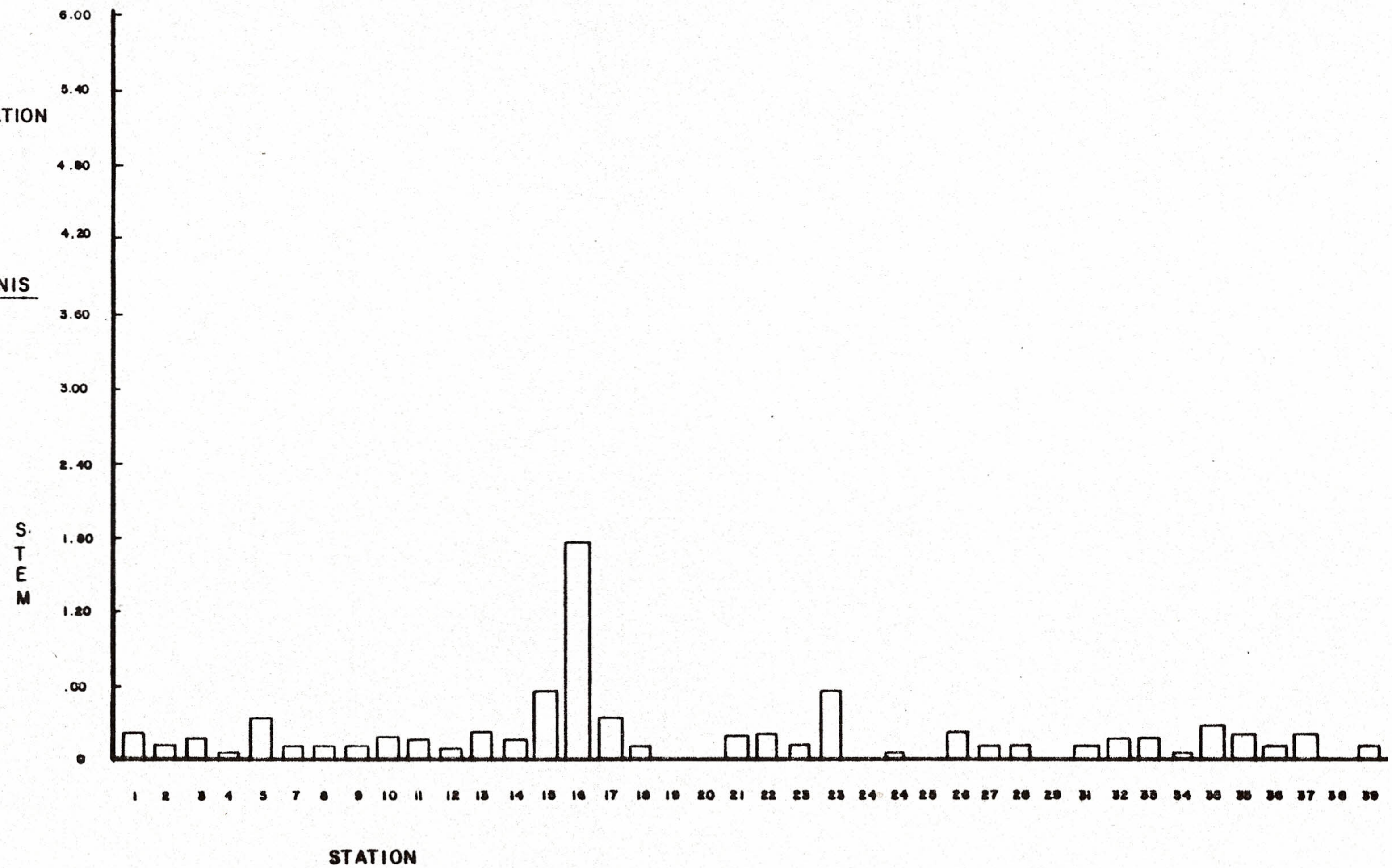
Fig. 16a	Phragmites Leaf
b	Phragmites Stem
c	Phragmites Rhizome
d	Phragmites Fruit Structure
e	Spartina Leaf
f	Spartina Stem
g	Spartina Rhizome
h	Spartina Fruit Structure

MERCURY CONCENTRATION

(ppm)

OF STEM TISSUE

PHRAGMITES COMMUNIS

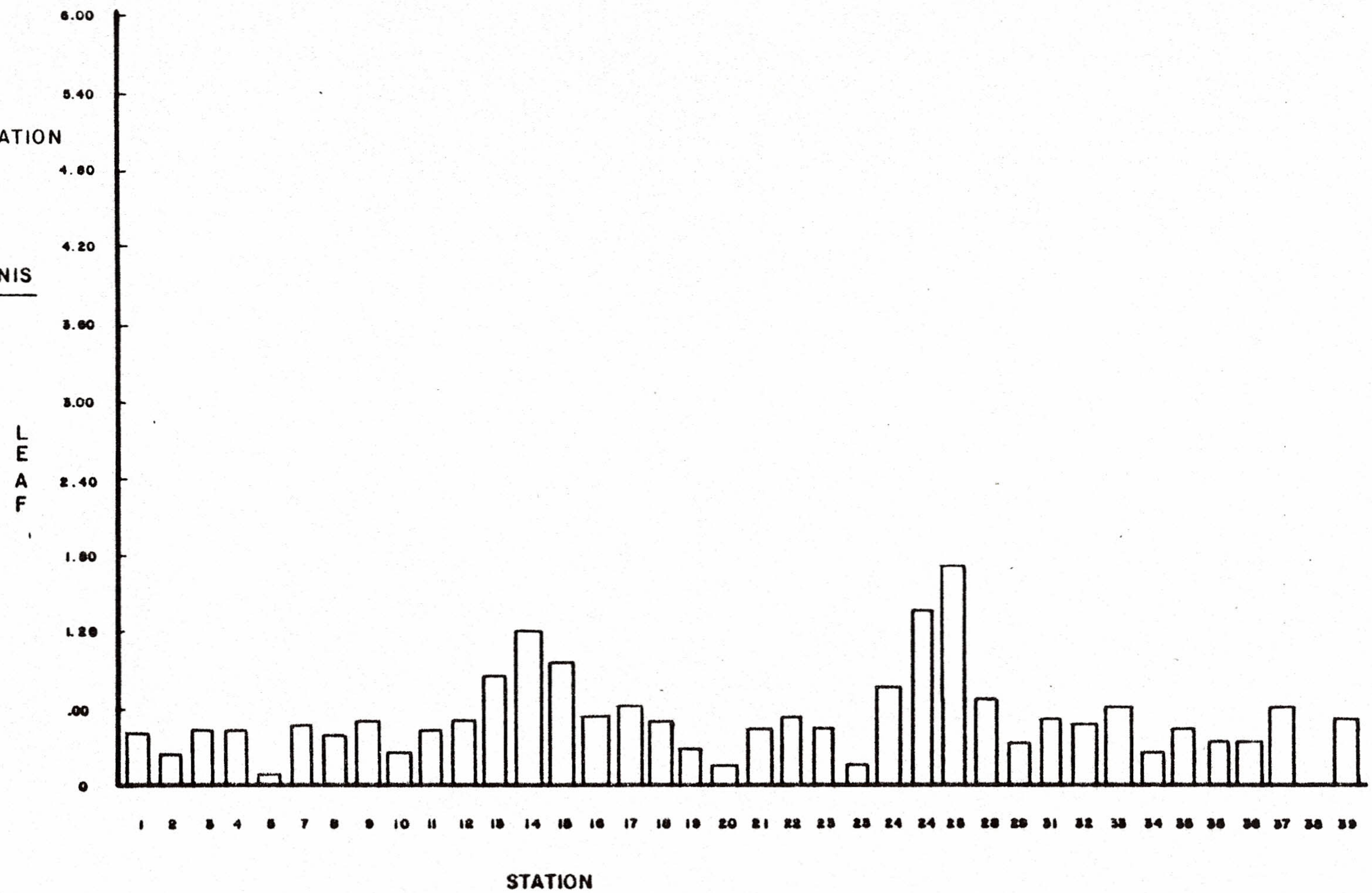


MERCURY CONCENTRATION

(ppm)

OF LEAF TISSUE

PHRAGMITES COMMUNIS

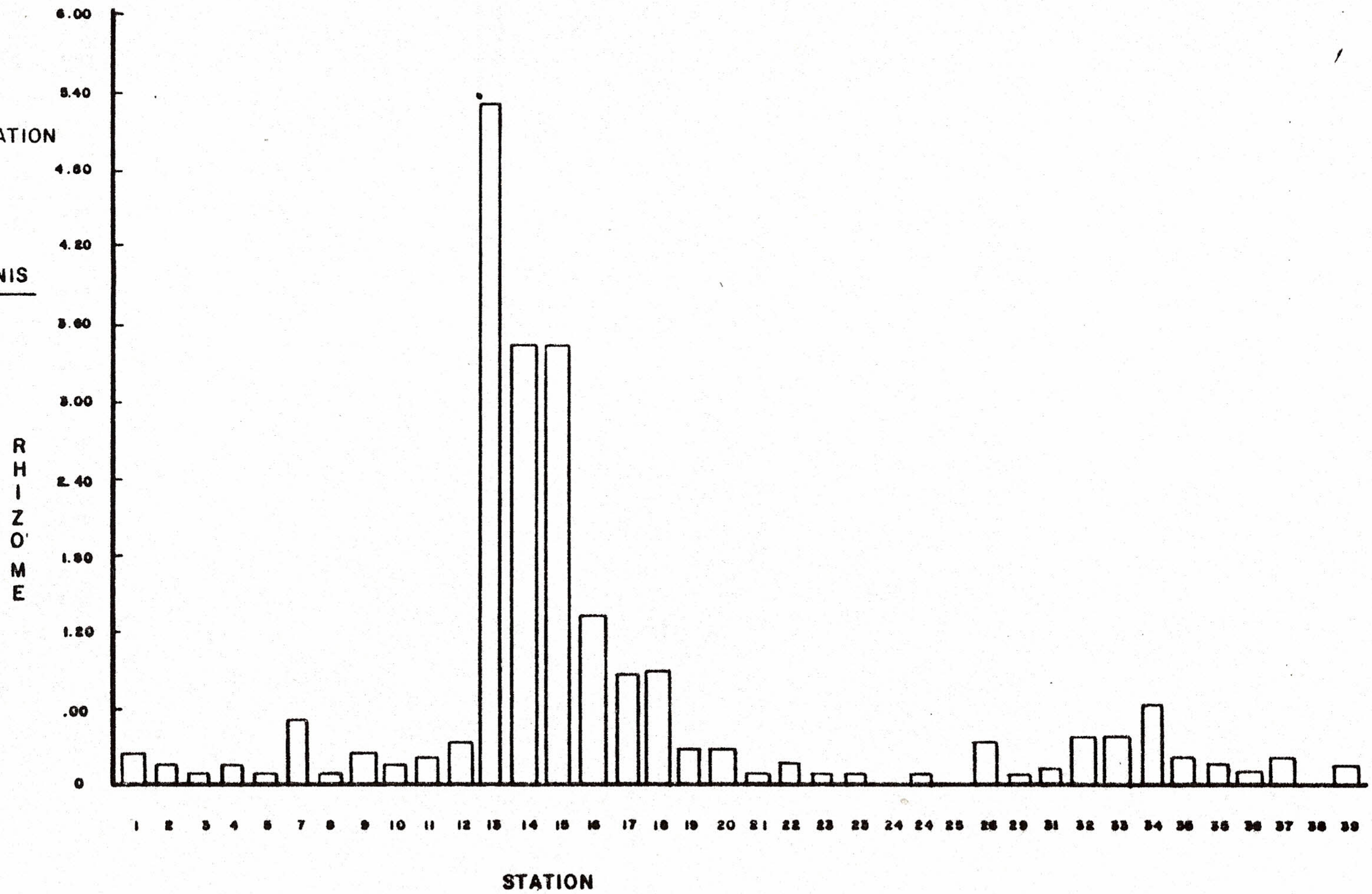


MERCURY CONCENTRATION

(ppm)

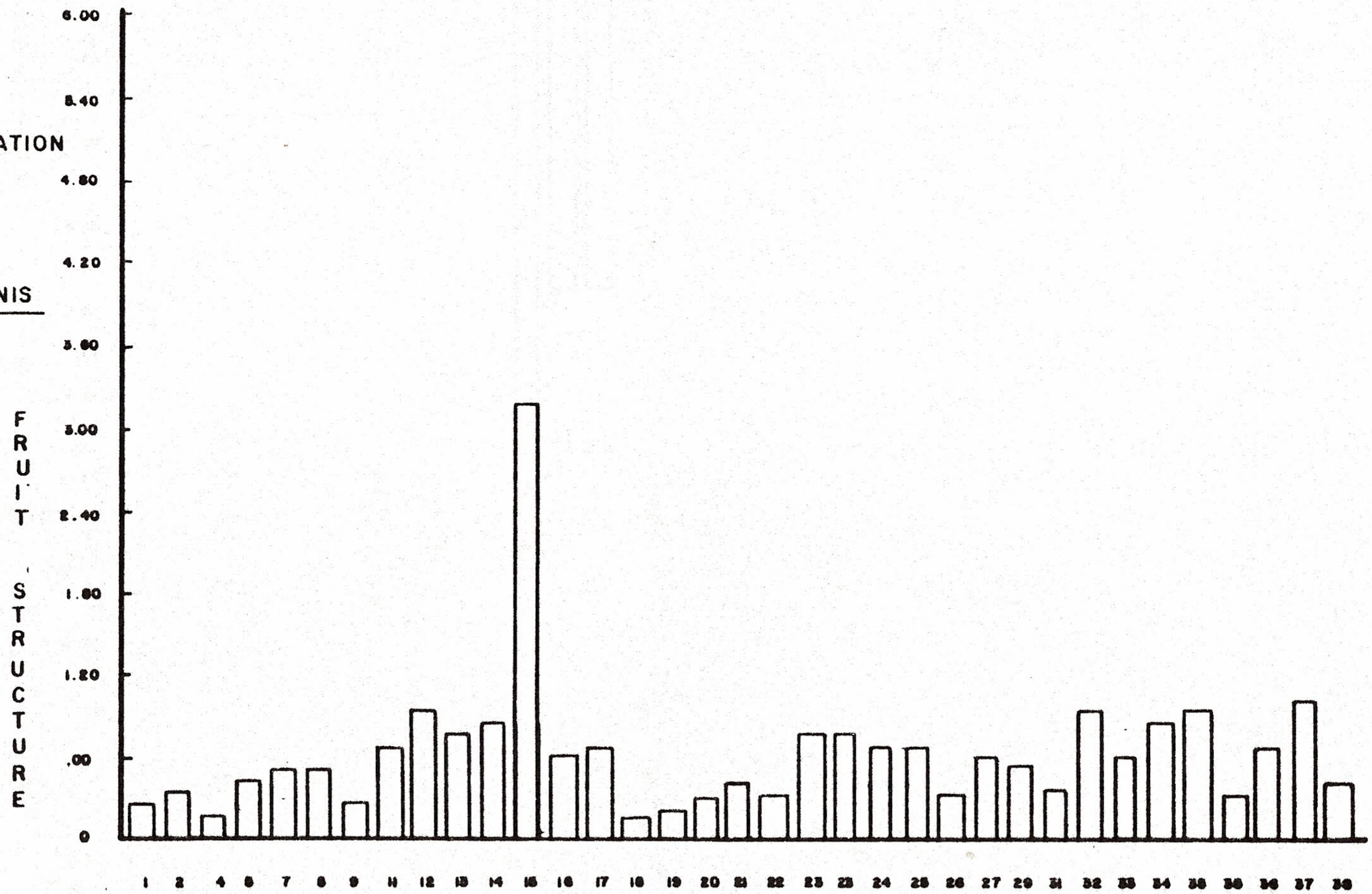
IN RHIZOME TISSUE

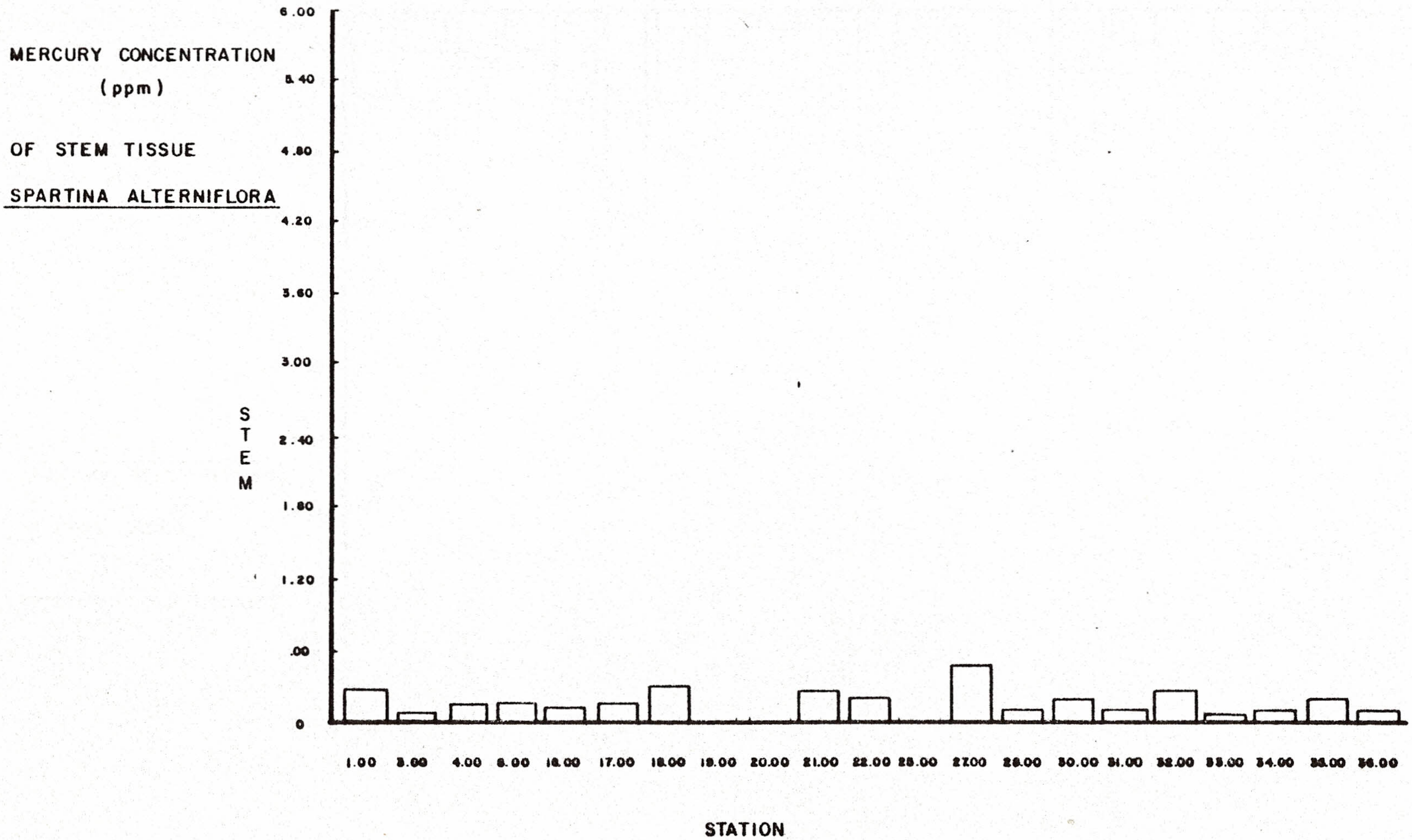
PHRAGMITES COMMUNIS



MERCURY CONCENTRATION
(ppm)
OF FRUIT TISSUE

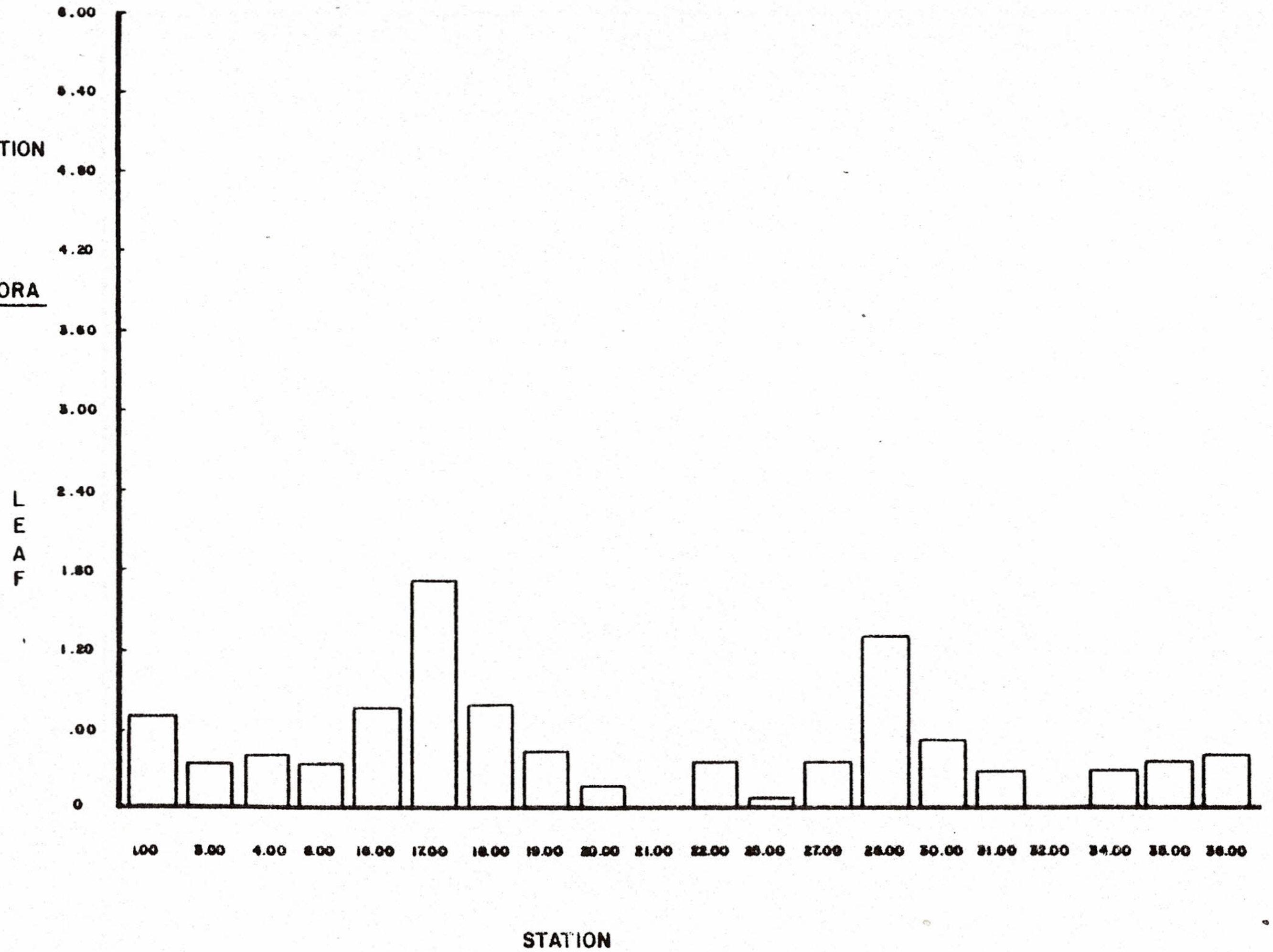
PHRAGMITES COMMUNIS





MERCURY CONCENTRATION
(ppm)
OF STEM TISSUE
SPARTINA ALTERNIFLORA
6.00
3.00
2.40
1.20
0
STEM
1.00
4.00
17.00
18.00
19.00
20.00
21.00
22.00
27.00
30.00
31.00
34.00
36.00
STATION

MERCURY CONCENTRATION
(ppm)
IN LEAF TISSUE
SPARTINA ALTERNIFLORA

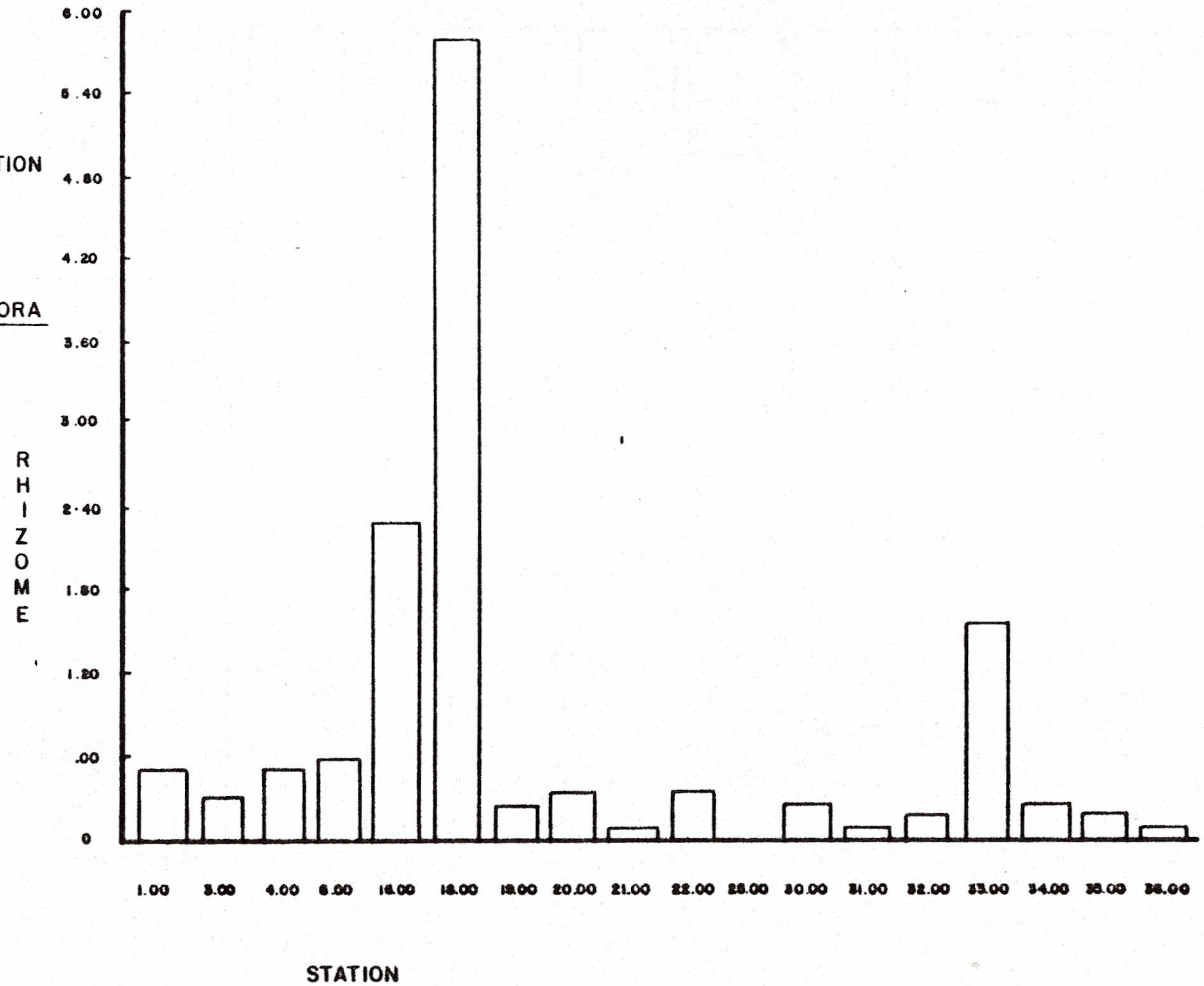


MERCURY CONCENTRATION

(ppm)

OF RHIZOME TISSUE

<u>SPARTINA ALTERNIFLORA</u>



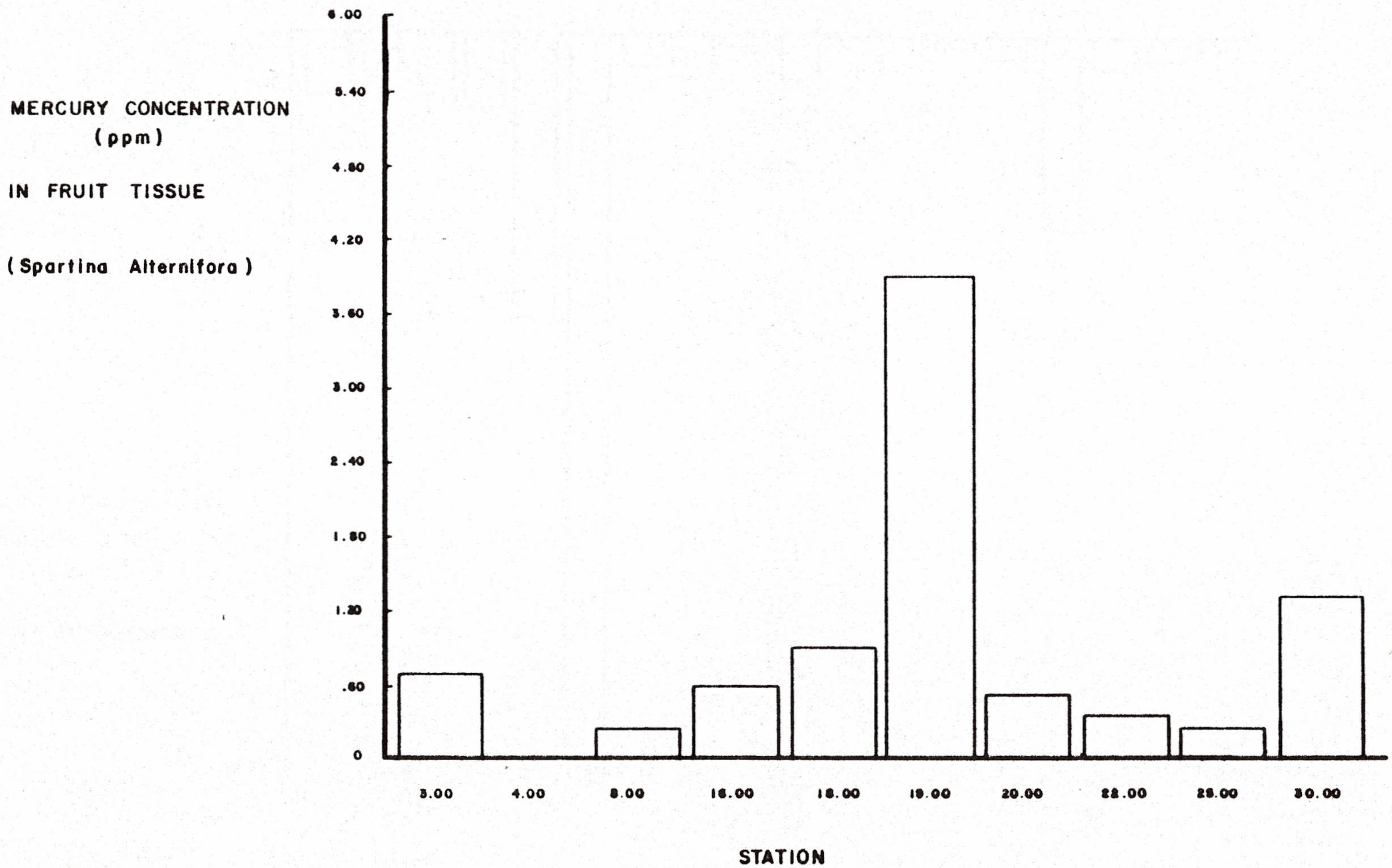

MERCURY CONCENTRATION
(ppm)
IN FRUIT TISSUE
(Spartina Alternifora)
6.00
5.40
4.80
4.20
3.60
3.00
2.40
1.80
1.20
.60
0
3.00
4.00
8.00
16.00
18.00
19.00
20.00
22.00
28.00
30.00
STATION

TABLE 1

MERCURY LEVELS IN SOILS (in ppm)

	Mean (ppm)	Range	Ref.
Sweden	.07*	.01-1.0	(1)
Finland	.06*	.02-.20	(1)
England	.06*	.01-15	(1)
Scotland	.08*	.01-2.	(1)
Japan	.28*	.18-.33	(1)
United States	.07*	.01-4.7	(1)
Georgia Salt Marsh	.07*	.02-.16	(2)
Washington D.C.-Urban	.48	.07-7.8	(3)
-Suburban	.16	.03-1.1	(3)
Evansville, Ind.-Urban	.27	.04-3.6	(3)
-Suburban	.09	.04-.25	(3)
Pittsfield, Ma.-Urban	.33	.11-2.5	(3)
-Suburban	.17	.07-.27	(3)
Des Moines -Urban	.44	.00-15	(3)
-Suburban	.01	.00-.15	(3)
Pittsburgh -Urban	.64	.11-2.1	(3)
-Suburban	.09	.00-.74	(3)
Levels near mercury deposits	250		(4)

* Geometric Mean

Table 2

Concentration of mercury in soils surrounding the Velsicol/Wolf site -JMA - 1977

Station No.	Depth (ft)	Hg (ppm)
W1	0-2	273
	2-4	376
	4-6	42
	6-8	0.7
	8-10	1.3
	10-12	1.1
W2	0-2	3.1
	2-4	5.2
	4-6	11.5
	6-8	263
	8-10	707
	16-18[a]	143
W3	0-2	19.6
	2-4	8.4
	10-12[a]	1.8
	12-14	1.3
	14-16	1.5
W4	0-2	1.5
	2-4	6.8
	10-12[a,b]	1,069
	12-14	172
	14-16	2.1
	16-18	2.1
W5	0-2	419
	2-4	66
	4-6	602
	6-8	1,043
	8-10	80
	12-14[a]	1.9
W6	0-2	2,592
	2-4	1,630
	4-6	1,080
	8-10[a]	7.7
	12-14[a]	9.3
	14-16	8.9
W7	0-2	193
	2-4	234
	4-6	83
	6-8	58
	8-10	1.8
W8	0-2	432
	2-4	105
	4-6	1.9
	8-10[a]	0.7
	10-12	1.2
	12-14	1.3

Station No.	Depth (inches)	Hg (ppm)
1S	0-6	4.8
	6-12	1.9
2S	0-6	6.4
	6-12	3.5
3S	0-6	6.1
	6-12	2.6
4S	0-6	619
	6-12	746
5S	0-6	2.4
	6-12	18.5
6S	0-6	1.5
	6-12	2.0
7S	0-6	15.4
	6-12	4.7
	12-18	7.1
	18-24	3.9
8S	0-6	58
	6-12	117
	12-18	61
	18-24	850
9S	0-6	30
	6-12	23
	12-18	13.8
	18-24	8.4
10S	0-6	46
	6-12	8.6
	12-18	10.0
	18-24	13.7
11S	0-6	25
	6-12	14.1
	12-18	19.5
	18-24	32
12S	0-6	22
	6-12	25
	12-18	43
13S	0-6	151
	6-12	2,008
	12-18	1,294
	18-24	654

(continued)

Station No.	Depth (inches)	Hg (ppm)
14S	0-6	221
	6-12	276
	12-18	63
	18-24	123,000
15S	0-6	5.7
	6-12	5.5
	12-18	6.8
	18-24	9.8
16S	0-6	20.2
	6-12	26
	12-18	39
	18-24	23
17S	0-6	11.1
	6-12	11.9
	12-18	14.8
	18-24	12.9
18S	0-6	9.2
	6-12	3.9
	12-18	5.2
	18-24	19.9
19S	0-6	23
	6-12	18.4
	12-18	197
	18-24	328
20S	0-6	75
	6-12	34
	12-18	19.4
	18-24	15.1
21S	0-6	546
	6-12	1,444
22S	0-6	367
	6-12	1,185
23S	0-6	2,558
	6-12	2,885
	12-18	3,397
	18-24	4,719

TABLE 3

Mean Mercury Concentration In
Marsh Soils and Channel Sediments
At 0-4" and 0-18" Depths

	MARSH SOILS		CHANNEL SEDIMENTS	
	MEAN MERCURY (ppm)		MEAN MERCURY (ppm)	
SITE	0-18"	0-4"	0-18"	0-4"
1	16	12	2	4
2	2	3	N.D.	N.D.
3	28	38	3	3
4	1	N.D.	.1	N.D.
5	9	8	N.D.	N.D.
6	1	2	10	20
7	23	24	7	10
8	24	23	2	3
9	30	46	9	10
10	19	13	N.D.	N.D.
11	.1	.2	1	1
12	16	22	16	15
13	·1	.3	-	-
14	18	23	N.D.	N.D.
15	10	10	N.D.	N.D.
16	10	16	5	8
17	6	12	1	2
18	983	385	904	541
19	161	322	58	128
20	57	82	153	248
21	104	41	4	8
22	32	25	1	2
23	31	35	7	10
24	16	25	7	8
25	10	6	8	8
26	18	10	12	7
27	5	7	2	3
28*	2	2		
29*	.3	.3		
30*	7	7		
31*	.3	.3		
32	18	10	.8	1
33	8	7	.5	.5
34*	.2	.3		
35*	8	7		
36	2	2		
37	.6	.5		
38	.3	.4		
39	3	6	.2	.2
40	97	111	79	91
41	27	9	13	16
42*	.2	.3	13	16
1A	331	338		
1B	567	908		
2	954	1730		
3A	41	78		
3B	184	342		
4	703	1535		
5	52	130		

* Mud Flat
N.D. - Non Detectable

TABLE 4

Mercury in N.J. Surface Waters

Range Mercury (ppb)	Sampling Sites Northeastern N.J.*	Hackensack River ** (excluding Berrys Cr.)	Berry's Creek ***
	n (%)	n (%)	n (%)
.d.-.1	103(70%)	33(30%)	3(3%)
1-.2	16(11%)	33(30%)	1(2%)
2-.3	22(15%)	15(13%)	2(3%)
3-.4	2(1%)	9(8%)	5(8%)
4-.5	1(1%)	6(5%)	6(9%)
5-.8	1(1%)	7(6%)	9(14%)
8-1.2	0	1(1%)	17(26%)
.2+	0	6(6%)	24(36%)

* The data under this column represents the number of samples falling within the listed range of mercury concentrations. 146 samples were collected from river basins in the northeastern portion of N.J. including Essex, Hudson, Union, and Bergen Counties. These samples were collected by DEP and analyzed by Rutgers U. as part of a surface water monitoring study being conducted by the Office of Cancer and Toxic Substances Research.

** The data under this column was obtained from HMDC (1978) study of mercury in surface water in the Hackensack Meadowlands. The data represents a summary of results collected from 5 stations in the Hackensack River excluding Berry's Creek. These stations were sampled 11 times on a monthly basis at high and low tides.

*** The same as above, except the data represents the results of sampling 3 stations in Berry's Creek 11 times on a monthly basis at high and low tides.

TABLE 5

Date Summary
Mercury Air Monitoring
August 1978

Station	Dates	24-hr. values (ug/m3)	12-hr. values ug/m3)	8-hr. values ug/m3
Site 1	8/14			.38
	8/15			.74
Site 1	8/10-11	1.02	---	.55
	8/11-12	.46	.47	.38
	8/12-13	.52	.38	.44
	8/13-14	1.01	.79	.72
	8/14	---	1.65	---
	8/14	---	1.54	---
	Av(8/10-14)*	.76		
Site 3	8/10-11	---	---	1.68
	8/11-12	.29	.21	.25
		.29		
	8/12-13	.39	.18	.50
		.27		
	8/13-14	1.02	.38	1.37
		.75		
	8/14-15	2.85	1.00	3.26
		2.40		
	Av(8/11-15)*	1.03		
Site 4	8/12-13	.20		
	8/13-14	2.09		
	8/14-15	2.21		
	Av(8/12-15)*	1.50		

* Average of 24 hour samples only.

TABLE 6

Average Mercury Concentrations in Air (ug/m^3)

			REF
Oceanic -	Particulate	.00015	2
	Vapor	.0007	2
Urban Areas -	Particulate	.0024	2
	Vapor	.007	2
Industrial		.007-5,000	2
Sewage Treatment Plan (Tenn.)		.016-600	1
Sewage Treatment Plant (Ky.)		.55-2.63	1
Ambient	- El Paso (Tx.)	.0296	1
	- Oakland	.0144	1
	- San Francisco	.0103	1
	- Louisville	.0059	1
Ambient -	Camden (NJ)	.002	13
(particulate)	Newark	.0004	13
	Rutherford	.0011	13
	Elizabeth	.0005	13
	Linden	.0002	13

Table 7

Mercury concentrations in Aquatic Organisms-HMDC report

	Kilifish			Carp			White Perch			Blue Claw Crab		
Location	$\bar{X}$(ppm)	n	(range)	$\bar{X}$	n	(Range)	$\bar{X}$	n	(Range)	$\bar{X}$	n	(Range)
Bellmans Cr.	.07	5	(.06-.18)									
Washout Cr.	.11	20	(.03-.22)									
Moonachie Cr.	.13	2	(.13-.13)									
Cromakill Cr.	.11	8	(.10-.18)									
West Riser	.09	10	(.04-.18)									
-Pumphouse	.09	10	(.04-.18)	.29	6	(.13-.53)						
-Tidegate	.25	10	(.08-.69)									
Berrys Cr.												
-East Riser	.17	10	(.10-.37)									
-Tide Marsh	.19	10	(.06-.25)									
-Triboro Sewage	.25	4	(.14-.41)									
-Service Rd	.25	2	(.24-.26)									
-South Service	.26	9	(.00-.54)									
-Canal	.21	15	(.07-.44)				.71	8	(.30-1.9)			
-Transco Br.	.35	10	(.20-.79)									
-Confl. Hack.	.02	2	(.01-.02)									
Sawmill Cr.												
-E. of Tpk.	.30	12	(.13-.54)	.28	2	(.27-.31)						
-Mouth	.36	10	(.07-.87)	.05	1		.71	3	(.47-.95)			
-W. of Tpk.										.23	8	(.10-.76)
Hackensack R.										.33	2	(.29-.38)
Windy Ditch	.54	12	(.30-.87)									

PSE+G Hudson Station Jersey City	Alewife	.66	5	(.47-.81)
	Herring	1.3	5	(.78-1.7)
	Anchovy	.71	1	(-)
	Shad	1.6	1	(-)
	Weakfish	.67	5	(.44-1.0)
	Bluefish	.72	1	(.48-.96)

TABLE 8

MERCURY CONCENTRATIONS IN AQUATIC ORGANISMS
COLLECTED FROM THE HACKENSACK MEADOWLANDS
BY THE NEW JERSEY MARINE SCIENCES CONSORTIUM *

Species	Mean (ppm)	No. of fish in Collection	Range
1. Hackensack River and Overpeck Creek			
Kilifish	.12	1	-
Black Crappie	.04	1	-
Golden Shiner	.06	1	-
Alewife	.04	1	-
White Perch	.20	6	.11-.32
Redfin Shiner	.16	1	-
Grass Shrimp	.07	2	n.d.-.07
Carp	.07	1	-
Bluegill Sunfish	.29	4	.22-.34
2. Hackensack River and Berrys Creek			
Kilifish	.27	29	.06-.96
Grass Shrimp	.42	2	.31-.54
Blue Claw Crab	.13	1	-
Striped Bass	.93	1	-
Eel	.33	1	-
3. Berrys Creek and Tidegate			
Kilifish	.52	9	.18-1.3
Grass Shrimp	.09	1	-
4. Hackensack River and Sawmill Creek			
Grass Shrimp	.16	5	.1-.30
Kilifish	.42	15	.01-1.7
Blue Claw	.22	2	n.d.-.22

n.d. = non-detectable

* This data was obtained from bi-monthly reports 1-3.

Table 9 Special Scientific Survey along Berrys Creek.
July 26, 1978-N.J.M.S.C.

Sub-Station	Mercury concentration Kilifish(ppm)*	Average
A	.14	
	.09	.13
	.15	
B	.12	.16
	.19	
C	.15	.15
D	.19	.19
E	.08	
	.13	.13
	.17	
	.19	
F	.15	.15
G	.21	.21
H	.12	
	.12	.18
	.16	
	.32	
I	.15	.15
	.14	

*The results listed here are for composited kilifish samples. Several fish were collected at each site, grouped according to size, homogenized; and a representative sample of the homogenate was then analyzed for mercury.

See Fig 13 for the locations of the sampling sub-stations.

TABLE 10

Seasonal Mercury Concentrations (ppm) in Killifish in the Meadowlands

Species	Sta.	Season	1≤#	#	$\overline{X}$	Range
Killifish	A	Su	1	6 (10,20)	0.49	(0.15-1.54)
		Fa	1	6 (10,30)	0.82	(0.15-2.2)
		Sp	0	3 (10,20)	0.29	(0.24-38)
	B	Su	0	9 (5,30)	0.36	(0.03-0.69)
		Fa	1	9 (10,20)	0.38	(0.08-1.05)
		Sp	0	3 (10)	0.19	(0.11-0.31)
	C	Su	0	8 (10,30)	0.39	(0.21-0.77)
		Fa	0	6 (7,20)	0.32	(0.20-0.60)
		Sp	0	6 (5,20)	0.24	(0.17-0.38)
	D	Su	0	7 (10)	0.41	(0.14-0.86)
		Fa	NC	---	---	---
		Sp	0	14 (5,10)	0.28	(0.13-0.78)
	E	Su	0	6 (10)	0.20	(0.09-0.40)
		Fa	3	10 (10,20)	0.77	(0.43-1.83)
		Sp	0	10 (10,30)	0.27	(0.16-0.50)
	F	Su	0	9 (5,30)	0.32	(0.11-0.61)
		Fa	0	9 (10)	0.11	(0.05-0.22)
		Sp	0	12 (10,30)	0.24	(0.10-0.47)
	G	Su	0	10 (10)	0.21	(0.09-0.35)
		Fa	0	8 (10)	0.16	(0.06-0.41)
		Sp	0	11 (5,30)	0.11	(0.07-0.21)

TABLE 10 (con't)

Seasonal Mercury Concentrations (ppm) in Killifish in the Meadowlands

Species	Sta.	Season	$1 \leq \#$	#	$\overline{X}$	Range
Killifish (con't)	H	Su	0	12 (10,20)	0.33	(0.13-0.52)
		Fa	0	10 (10,20)	0.11	(0.03-0.17)
		Sp	0	12 (5,20)	0.15	(0.06-0.24)
	I	Su	0	7 (10)	0.13	(0.02-0.23)
		Fa	0	10 (10,20)	0.10	(0.03-0.14)
		Sp	0	14 (10,20)	0.15	(0.07-0.34)
	J	Su	0	10 (10)	0.14	(ND-0.27)
		Fa	0	12 (10)	0.06	(0.02-0.09)
		Sp	0	15 (10,20)	0.11	(0.03-0.20)
	K	Su	0	3 (4,30)	0.01	(ND-0.02)
		Fa	NC	---	---	---
		Sp	0	6 (10,30)	0.09	(0.03-0.13)
	PP	Su	0	19 (10,30)	0.19	(ND-0.37)
		Fa	NC	---	---	---
		Sp	NC	---	---	---

- Whole fish composite samples
$1 \leq \#$ - Number of samples greater than the FDA 1 ppm mercury standard in fish
\# - Number of samples, ( ) number of individuals in composite species
X - Mean
ND - Not detected
NC - Not caught in sample
Su - Summer
Fa - Fall
Sp - Spring

TABLE 11

Range in Concentrations (ppm) of Mercury in Aquatic Fauna*

Station	Season	Alewife	Blue Crab	White Perch	Fiddler Crab	Assorted Species
F	Su	0.12-0.26	---	---	---	Weakfish 0.26
	Fa	0.02-0.13	0.02-0.31	---	---	---
	Sp	---	---	0.44		Pumpkinseed Sunfish 0.22 Bluegill Sunfish 0.13 Green Sunfish 0.11
G	Su	---	M 0.16-0.68	0.12-0.24	0.17-0.31	---
	Fa	---	M 0.08-0.31	---	---	---
	Sp	---	---	---	---	Carp (0.04-0.20)
H	Su	---	0.08-0.38	---	ND-0.29	American Shad 0.21
	Fa	0.12	---	---	0.02-0.09	---
	Sp	---	---	0.09	0.07-0.31	American Eel 0.12
I	Su	0.32	0.32	---	---	---
	Fa	---	---	---	---	---
	Sp	---	---	---	---	Carp 0.04
J	Su	0.37-0.72	0.15-0.21	0.18-0.58	ND-0.71	Weakfish 0.19-0.33 Carp 0.18
	Fa	0.07-0.14	0.09-0.14	---	0.02-0.1	---
	Sp	---	---	0.09	0.11-0.22	Carp M 0.04
K	Su	---	---	0.14-0.29	---	Brown Bullhead M 0.05-0.16 Carp 0.07-0.26 Pumpkinseed Sunfish 0.19-0.31
	Fa	---	---	0.04-0.08	---	Brown Bullhead ND-0.02 Carp 0.02
	Sp	---	---	M 0.05-0.30	---	Bluegill Sunfish (0.03-0.22) Pumpkinseed Sunfish (0.05-0.11)
PP	Su	---	M 0.26-0.65	---	---	---
	Fa	0.07-0.29	---	0.31	---	---
	Sp	---	---	---	---	---

* - Whole organism unless otherwise noted
M - Muscle
ND - Not detected
--- - Not caught in sampling
Su - Summer
Fa - Fall
Sp - Spring

Bibliography

1. U.S. EPA (1977), Multimedia Levels of Mercury, EPA 560/6-77-031, Office of Toxic Substances, Washington, D.C.

2. National Research Council (1978), An Assessment of Mercury in the Environment, Scientific and Technical Assessments of Environmental Pollutants, Environmental Studies Board, Commission on Natural Resources, National Academy of Sciences, Washington, D.C. 185 pp.

3. World Health Organization (1976), Environmental Health Criteria 1, Mercury. Geneva, Switzerland.

4. U.S. EPA (1978), An Assessment of Mercury Emissions from Fossil Fueled Power Plants, EPA-600/7-78-146, Interagency Energy/Environment R&D Program Report, Washington, D.C.

5. Windom, Herbert L. (1976), Geochemical Interactions of Heavy Metals in Southeastern Salt Marsh Environments, Published by U.S. EPA-600/3-76-023, Office of Research and Development, Corvallis Environmental Research Laboratory, Corvallis, Oregon.

6. Harriss, Robert C., and Christoph Hohenemser (1978), Mercury...Measuring and Managing the Risk, Environment 20, No. 9 p. 25.

7. U.S. Army Corp of Engineers Final EIS Permit to Construct an Embankment and Other Facilities on Berry's Creek, Bergen Co., N.J.

8. Council of Environmental Quality (1975), Sixth Annual Report of the Council of Environmental Quality, Washington, D.C.

9. N.J. Sports and Exposition Authority (1978), Full Environmental Impact Statement for the Proposed Meadowlands Areana, Prepared by JMA Inc.

10. Goldwater, Leonard, (1971), Mercury in the Environment, Scientific American 224, No. 5, p. 15.

11. Hartung Rolf, and Bertram D. Dinman eds. (1972), Environmental Mercury Contamination Ann Arbor Science Publishers, Ann Arbor, Michigan.

12. U.S. EPA (1976), Criteria for a Recommended Standard for Occupational Exposure to Inorganic Mercury, National Institute for Occupational Safety and Health, Washington, D.C.

13. Harkov, R. 1980 Second Report on the Findings of the State Monitoring Program for Heavy Metals and Polycyclic Aromatic Hydrocarbons in Ambient Air in New Jersey. New Jersey Department of Environmental Protection. 23 pp.